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SAMUEL PIERPONT LANGLEY.

JOHN A. BRASHEAR.

FOR POPULAR ASTRONOMY.

"The man of grand impulses sheds a lustre on all around him."

A great man has gone to his rest. A life filled with the highest aspirations has closed and we are left to mourn the loss of one whose place will be difficult to fill. The writer was associated with Professor Langley for more than thirty years, and in all those years he has only pleasant, aye delightful recollections of his personality, his magnificent intellect—one never satisfied with a half proven hypothesis—but always reaching out for final proof before he announced any of his great discoveries.

Not every man who came in contact with Professor Langley knew him as the writer knew him. Many times he has walked for miles with him. During the walk nothing would escape his lips but monosyllables. Was he cold—indifferent—callous to the questioner? Far from it. Some difficult—perhaps intricate problem in solar physics or other correlated study had taken possession of his mind to the exclusion of all else, and I have often thought that his "yes" or "no" to my questions were almost of an automatic character.

But how different at other times during our walks from the old Observatory to the nearest woods where now is erected the new Astronomical Observatory. Charming was his conversation from the beginning to the end of our stroll. When in this mood no man could be more entertaining and instructive than Professor Langley—indeed some of the most delightful remembrances of my long association with him come to me as I recall these delightful walks and talks.

When he was writing his New Astronomy—he would invite me to come to the Observatory in the evening and read to me a chapter of that splendid book. I call to mind the closing paragraphs of two that impressed me greatly, as he read them and

for fear I may not quote verbatim I refer to his chapter on the Moon where, in closing his charming description of its scenery, he says: "Let us leave here the desolation about us, happy that we can come back at will to that world, our own familiar dwelling where the meadows are still green and the birds still sing, and where better yet still dwells our own kind — surely *the* world, of all we have found in our wanderings, which we should ourselves have chosen to be our home."

Let me also quote the closing paragraph of his chapter on the Stars, which I heard him read "in the long ago," a beautiful illustration of the life history of man as compared to that of the stars:—"I have read somewhere a story about a race of ephemeral insects who live about an hour. To those who are born in the early morning the sunrise is the time of youth. They die of old age while his beams are yet gathering force, and only their descendants live on to midday; while it is another race which sees the Sun decline, from that which saw him rise. Imagine the Sun about to set, and the whole nation of mites gathered under the shadow of some mushroom (to them ancient as the Sun itself) to hear what their wisest philosopher has to say of the gloomy prospect. If I remember aright, he first told them that, incredible as it might seem, there was not only a time in the world's youth when the mushroom itself was young, but that the Sun in those early ages was in the eastern, not in the western sky. Since then, he explained, the eyes of scientific ephemera had followed it, and established by induction from vast experience the great "Law of Nature," that it moved only westward; and he showed that since it was now nearing the western horizon, science itself pointed to the conclusion that it was about to disappear forever, together with the great race of ephemera for whom it was created.

What his hearers thought of this discourse I do not remember, but I have heard that the Sun rose again the next morning."

Professor Langley was a lover of children. I have heard it from many friends whose homes he visited, how he would gather the little ones around him and tell them fairy stories, many of which he would improvise with wonderful tact to please the children.

A Washington lady had made several attempts to converse with Professor Langley—at receptions—upon his scientific investigations but failing to get the response desired, in her despair she asked him one evening what he did like to talk about. He quickly replied, "Children and fairy stories."

His beloved niece—the daughter of Professor John W. Langley who attended him in his last illness—told the writer that he took with him from Washington one of Andrew Lang's fairy story books which he read during his all too brief stay in South Carolina.

The writer of this brief sketch of Professor Langley's life feels totally inadequate for the task, but deems it a great pleasure to place on record some of the lovely traits of character on the side of "the humanities"—separate and distinct from his scientific work, for with all that apparent "calmest coldness" there was something reaching almost to the transcendental in his inner life—which my long acquaintance and association brought to light. I have given but a few instances of these pleasant reminiscenses, instances which could be multiplied many times.

The writer can never forget the generous help given him in the solution of optical problems, from the very beginning of his acquaintance with Professor Langley. I never visited the Smithsonian Institution while he was there, that he did not call to my mind the first night we met, when, with fear and trembling, I unwrapped from a red bandana handkerchief my first five-inch objective on which my wife and I had worked the spare time of three years. We had met with many discouragements and failures but that night I received such generous words of encouragement that the subsequent work on the objective was made easier by far.

Several years afterward when the writer had the good fortune to discover a method of polishing the rocksalt lenses and prisms for his spectro bolometric research—and giving them an accurate optical surface, his joy seemed to have no bounds, and I have letters from him expressive of his gratification, that are prized beyond measure.

It would be presumption for the writer to undertake to dilate upon the scientific labors of Professor Langley. They are too well known to the scientific world and especially to the readers of *Popular Astronomy*, to need repetition here, but a brief recapitulation of some of his more important work may not be without interest.

Professor Langley came by invitation to the Allegheny Observatory in 1867. Two years afterwards, 1869, he introduced standard time distribution to the cities and railroads. Inasmuch as there has been a great deal of controversy over the question of priority in this matter, a discussion of which would be out of place here, I will simply quote from an article written by Professor Langley more than twenty years ago.

"A mention of the Observatory's work would be incomplete without some account of its system of time distribution introduced by its present director in 1869. Previous to that date, time had been sent in occasional instances from American Observatories for public use but in a temporary or casual manner."

"The Allegheny system, inaugurated in that year, is believed to be the parent of the present ones used in this country in that it was so far as is known the first regular and systematic system of time distribution to railroads and cities adopting it as an official standard."

At the time this article was written signals were being sent over 4713 miles of railroad from the Allegheny Observatory. The closing paragraph of the article referred to will be of interest.

"For the benefit of any future writer of the history of the subject it may be stated that in 1870 the Allegheny Observatory had already in extended operation the system of time distribution above described; that about 1873 the director at Cambridge Observatory, after conference with the writer, introduced substantially the same provisions for connecting Harvard College Observatory with the New England roads; and that about the same time the Washington Observatory, which had previously sent signals in a limited and desultory manner, commenced to do so in emulation of the new system."

Professor Langley made good use of the income derived from the time service for the commencement of that long series of solar researches—which have added so much to our knowledge of the Sun. He was an exquisite draughtsman—as can be testified by the hundreds of beautiful drawings of solar phenomena made by him. Every student of Astronomy has seen reproductions of his charming drawing of the great sun-spot of December 1873—which has indeed become classic as a "typical" sun-spot. The sky of Allegheny with its murkiness often contributes to fine definition on the Sun, as the writer can testify, he having seen the delicate detail of the penumbral fringes come out like unto a steel engraving. The halcyon days of astronomical photography had not yet come when Professor Langley made his beautiful drawings.

Fortunately for Professor Langley's great work of the future, William Thaw, the staunch friend of the Observatory and one of the pioneers in its construction and equipment, became deeply interested in the director's solar work, and aided him in many ways. The income of the Observatory was so limited that little could be done in experimental research until William Thaw with a most

liberal hand and heart provided the means for carrying on this great work, and your readers will find at the close of almost every monograph written by Professor Langley—"This research was made possible through the liberality of a citizen of Pittsburg." By Mr. Thaw's request his name was never mentioned.

In his studies in the domain of solar physics, Professor Langley was early impressed with the idea that much of the radiant energy from the Sun was not recognized by the instruments then in use and after a long series of experiments, discovered and developed that marvelously delicate instrument, the bolometer. With the bolometer a series of investigations were commenced upon the Sun, Moon and stars, which were continued for many years, bringing to light some of the most important facts in the whole realm of astronomical physics.

Professor Langley, with his assistants, Professor Keeler, Professor Very, and Mr. Page, continued the study of the hitherto unknown region of solar radiation until the bolographic chart, reaching far down into the spectrum, and showing almost innumerable curves of selective absorption, was given to the world, as a most valuable contribution to our knowledge of radiant energy. Although this great work was thought to be nearly completed before Professor Langley accepted the secretaryship of the Smithsonian Institution at Washington, he had continued the experimental research in the same field, at the astrophysical observatory connected with the Institution with a more refined equipment, but instead of the visual, using the photographic method, yet nothing has been developed to change the results of the Allegheny Observatory research. After years of study at Allegheny upon the problem of the selective absorption of the Earth's atmosphere at the lower levels, Professor Langley desired to make a similar investigation at a very high altitude. The top of Mt. Whitney in southern California was selected, as well as a station about two miles below the peak. William Thaw provided most of the means for the now famous expedition, our own government also sharing in the expenses of the research. Professor Keeler and Dr. William Day assisted Professor Langley in the work of this expedition, the results of which have now become classic, indeed have to a large degree settled the problem of the selective absorption of the Earth's atmosphere in its relations to the Sun's radiant energy, and the intimately correlated problem of life upon our globe. Professor Langley found time to study many minor though important questions bearing upon radiant energy, not alone from the Sun, but from other sources. His studies of the

Moon's temperature added immensely to our knowledge of the "lesser light that rules the night". With the spectrobolometer, the highest temperature of the Moon was found to be about zero centigrade, and the lowest temperature not far from the temperature of space.

Professor Langley's work in mapping the invisible spectrum was a herculean task. Aided by Professors Keeler, Very and Page, thousands of measurements were made with the spectrobolometer and read visually, before the photographic method was devised and developed so beautifully by Professor Langley and his co-workers at the Smithsonian. Well do I remember how many times the rockslat trains were brought over to our workshop from the old Allegheny Observatory say about ten o'clock in the morning of a bright day, with the request that they be *polished and figured by noon*! I do not remember ever to have disappointed these good people in the matter of their request.

The subsequent mapping of the infra red spectrum by photography at the Smithsonian Astrophysical Observatory has been a magnificent piece of work and to Professor Langley's assistant in later years, Mr. Abbot, must be given a share of the credit which he so well deserves.

More recently Professor Langley became deeply interested in the problem of *variable* solar radiation, in which he was greatly assisted by Mr. Abbot and his associates, and although the research had not been completed at the time of his death—he was convinced by results already obtained, that our Sun is a variable with rather a larger coefficient than has even been suspected.

Of his work in the domain of aerodromics the writer wishes to say a few words. The story is a long one of how Professor Langley became interested in the problem of flight—but suffice it to say here that his original purpose was *not* to construct a flying machine but if possible to determine the *laws governing flight*, and I am sure that Professor Very and others associated with Professor Langley in this most fascinating problem will bear me out in this that he undertook to solve it in a rigorously scientific manner. His invention of the dynanometer chronograph aided largely in this research. Nothing was left to guess at—every experiment with birds and aeroplanes was as carefully carried out as were his astrophysical studies. For three years the writer was associated with his friend Professor Langley in his investigations on this great problem, and I must add my testimony to that of others that every thing was conducted in the true scientific spirit—and though in his later work on mechanical flight at the

Smithsonian, success or failure cheered or depressed him—he has left on record most valuable facts that must be of inestimable value to those who desire to push forward this fascinating study.

Professor Langley received many honors during his life time. To be called as the successor of Professor Baird as secretary of the Smithsonian Institution was the highest gift in a scientific sense that could be conferred upon him by his country. Oxford conferred upon him the degree of D. C. L., Cambridge, the degree of D. Sc., Harvard, Princeton, University of Michigan and the University of Wisconsin, conferred upon him the degree of LL.D.

He was a correspondent of the French Academy, a Foreign member of the Royal Society, a Fellow of the Royal Astronomical Society, and other scientific associations. He received the Henry Draper, Count Rumford, Janssen, and other medals for his splendid discoveries.

Many of Professor Langley's works had great literary beauty. One has only to read the pages of his "New Astronomy" to be charmed with the beauty and clearness of his methods, and no matter how abstruse the subject, he seemed to have the ability to make it plain and thus appreciated even to the lay reader, who, though not an investigator, had a love for the subject discussed.

I quote from the words of a friend:

"Professor Langley had a deep interest in all that related to things of the mind, and was for many years associated with both the American and British Associations for Physical Research. He was an omnivorous reader of everything that was best in English and French literature, and was especially interested in George Borrow. He was the owner of a considerable collection of Borrow's manuscripts, and was a student of French history and memoirs. His interest in the fine arts was keen, and he had many times visited the galleries of Europe and knew the great pictures everywhere. The orient had a fascination for him, and he had a collection of the editions of the "Arabian Nights." As a young man he was a great admirer of Thomas Carlyle, with whom he had an acquaintance, and to whose home he made several pilgrimages. He had a great love for little children, and the "children's room" in the Smithsonian building was the result of his personal care and attention.

Professor Langley was born in Roxbury, Mass., August twenty-second, 1834. On the twenty-second of November last he suffered a slight stroke of paralysis but recovered sufficiently to be taken to Aiken, S. C., where he was attended by a faithful nurse and

his beloved niece, the daughter of his brother, Professor John W. Langley. Professor Langley wrote several letters from Aiken to his friends, particularly to those associated with him in the Smithsonian Institution, and great hopes were entertained that his recovery was only a matter of time, but it was not so to be. A second stroke came as "a thief in the night" but brought no pain to our friend—and after two days of apparently quiet sleep, broken at intervals—he passed away to the "Summer Land of Song," on the twenty-seventh day of February, 1906. His body was brought to Washington and the funeral services held in All Souls Church. The venerable Edward Everett Hale, an old time friend of Professor Langley, spoke most fitting and kindly words at the brief services. The Regents of the Smithsonian Institution acted as honorary pall bearers, and the members of the Smithsonian staff as active pall bearers.

The remains were taken to Boston in a private car, where they were laid away in Forest Hills Cemetery by the side of his mother. His intimate friend Dr. Adler informed the writer that this was Professor Langley's expressed wish. A short address was delivered at the cemetery by his friend Alexander Graham Bell, in which he gave a brief resumé of Professor Langley's life work.

When Napoleon stood at the edge of the battlefield where a great victory had been won by his soldiers, his ears were deaf to the groans of the wounded and dying, he heard them not, but said to his generals— in the ecstacy of victory

"C'est magnifique."

When our own Langley stood on the summit of the old Allegheny hills where so much of his life work had been done—and watched the Sun setting in all his glory, we heard him exclaim—"It is magnificent." Now that he is gone, and we look over the fields of science where he has won his grand but bloodless victories—we can but add our final tribute by repeating the words—

"It is magnificent."

Allegheny, Penn.

GEOLOGICAL TIME.

WARREN UPHAM.

FOR POPULAR ASTRONOMY.

The astronomer and the geologist ask, but cannot decisively answer, the question considered in this paper, "How old is the Earth?" It is surely known to be very old, as compared with the

span of human history; but the wide range of the most expert estimates and theories leaves it undetermined whether the measure of geological time is less than a hundred million years, or may be five to ten or twenty times longer. Investigations will be continued, we may hope, until a more satisfactory and convincing answer to this question shall be ascertained, with such fullness of evidence that it must receive general approval and acceptance

Numerous eminent writers who have considered this subject from the standpoint of physical experiment and theory and their relationship with astronomy, including Lord Kelvin, Tait, Newcomb, Young and Ball, tell us that geologists can be allowed probably no more than one hundred millions of years, and perhaps only about ten millions, since our Earth was so cooled as to permit the beginning of life upon it. The series of geologic eras, so far as they are known from fossil faunas and floras, is only a part, perhaps a half or a third, or less, of the earth's age as a separate planet.

According to the nebular theory of Laplace, the physicist and astronomer, looking beyond the beginning of geology, see our solar system in the process of slow but very grand evolution, from a globular nebulous mass with as great circumference as the orbit of the outermost planet whose mass became first detached from the revolving nebula, followed successively by the inner planets to Mars, the Earth, Venus, and Mercury, till finally the chief residual part of the nebula became the splendidly luminous Sun. In like manner, as the planets became condensed to their present forms, most of them suffered a like severance of comparatively small portions of their masses to form moons and for Saturn both moons and rings. From measurements of the rate of radiation of the Sun's heat, from the rate of downward increase of the Earth's heat observed in deep mines and borings, and from experiments in the laboratory, aided by elaborate mathematical calculations, the physicist determines, to his own satisfaction, how long the Sun can have been the center of light and life for his attendant planets, how long time has passed since the Moon's mass was thrown off from our whirling world, then revolving more rapidly than to-day, and the duration of the ages since the once molten Earth became encrusted and so far cooled that its ocean ceased to boil and vegetation and animal life began.

In researches based on premises of that nebular theory, Sir William Thomson (now Lord Kelvin) long ago estimated, from his study of the Earth's internal heat, its increase from the sur-

face downward, and the rate of its loss by radiation into space, that the time since the consolidation of the surface of the globe has been somewhere between 20 millions and 400 millions of years, and that most probably this time and all the geologic record must be limited within 100,000,000 years. Professor George H. Darwin computes, from the influence of tidal friction in retarding the Earth's rotation, that probably only 57,000,000 years have elapsed since the Moon's mass was shed from the revolving Earth, long before the formation of its crust. From the same arguments and the rate at which the Sun is losing its store of heat, Professor Guthrie Tait affirms that apparently 10,000,000 years are as much as physical science can allow to the geologist. Professor Newcomb, summing up the results of these physical and astronomic researches, writes: "If the Sun had, in the beginning, filled all space, the amount of heat generated by his contraction to his present volume would have been sufficient to last 18,000,000 years at his present rate of radiation . . . . . 10,000,000 years . . . . . is, therefore, near the extreme limit of time that we can suppose water to have existed on the Earth in the fluid state." Not only the Earth, but even the whole solar system, according to Newcomb, "must have had a beginning within a certain number of years which we cannot yet calculate with certainty, but which cannot much exceed 20,000,000, and it must end."

The geologist demurs against these latter far too meager allotments of time for the wonderful, diversified, and surely vastly long history which he has patiently made out in his perusal of the volume of science disclosed by the rocks. He can apparently do very well with Lord Kelvin's original estimate, but must respectfully dissent from the less liberal opinions noted. Somewhere in the assumed premises which yield to mathematicians these narrow limits of time, there must be conditions which do not accord with the actual origin and constitution of the Sun and Earth. It must be gratefully acknowledged, however, in the camp of the geologists, that we owe to these researches a beneficial check against the notion once prevalent that geologic time extends back practically without limit; and it is most becoming for us carefully to inquire how closely the apparently conflicting testimonies of geology and of physics may be brought into harmony by revision of each.

Among all the means afforded by geology for direct estimates of the Earth's duration, doubtless the most reliable is through comparing the present measured rate of denudation of continental

areas with the aggregate of the greatest determined thickness of the strata referable to the successive time divisions. Now the rates at which rivers are lowering the altitudes of their basins by the transportation of sediments to the sea vary from an average of one foot taken from the land surface of its hydrographic basin by the River Po in 730 years to one foot by the Danube in 6,800 years. As a mean for all the rivers of the world, Alfred Russel Wallace assumes that the erosion of all the land surface is one foot in 3,000 years. The sediments are laid down in the sea on an average within 30 miles from the coast, and the coast lines of the Earth have a total measured length, according to Dr. James Croll and Mr. Wallace, of about 100,000 miles, so that the deposition is almost wholly confined to an area of about 3,000,000 square miles. This area is one nineteenth as large as the Earth's total land area; hence it will receive sediment nineteen times as fast as the land is denuded, or at the rate of about nineteen feet of stratified beds in 3,000 years, which would give one foot in 158 years. With this Wallace compares the total maxima of all the sedimentary rocks of the series of geologic epochs, measured in whatever part of the Earth they are found to have their greatest development. Professor Samuel Haughton estimates their aggregate to be 177,200 feet, which multiplied by 158 gives approximately 28,000,000 years as the time required for the deposition of the rock strata in the various districts where they are thickest and have most fully escaped erosion and redeposition.

It is comparatively easy to determine the ratios or relative lengths of the successive geologic eras, but confessedly very difficult to decide beyond doubt even the approximate length in years of any part of the records of the rock strata. The portions for which we have the best means of learning their lengths are the Glacial and Recent periods, the latter extending from the Champlain epoch or closing stage of the Ice age to the present time, while these two divisions, the Glacial or Pleistocene period and the Recent, make up the Quaternary era. If we can only ascertain somewhat nearly what has been the duration of this era, from the oncoming of the Ice age until now, it will serve as a known quantity to be used as the multiplier for giving us the approximate or probable measures in years for the recedingly earlier and far longer Tertiary, Mesozoic or Secondary, Paleozoic or Primary, and Archean or Beginning eras, which last takes us back almost or quite to the time when the cooling molten Earth became first enveloped with a solid crust.

The ratios reached by Professors J. D. Dana and Alexander Winchell from the thicknesses of the rock strata, are closely harmonious, the durations of Paleozoic, Mesozoic, and Cenozoic time being to each other as 12:3:1. The Tertiary and Quaternary ages, the latter extending to the present day, which are here united as the Cenozoic era, Dana would rank approximately in the ratio of 3:1, giving to the Quaternary a sixty-fourth part of all time since the beginning of the Cambrian period, to which our earliest well preserved fossil faunas belong. His estimate of the relative length of Quaternary time seems to me greatly exaggerated; but this would not sensibly affect the general ratios. Dana further ventured a supposition that these three vast eras from the Cambrian down until now, may comprise some 48,000,000 years, which would give for the Paleozoic era, 36,000,000 years; the Mesozoic, 9,000,000; and the Cenozoic, 3,000,000. He disclaimed, however, any assumption that these figures are "even an approximate estimate of the real length of the interval, but only of relative lengths, and especially to make apparent the fact that these intervals were *very long*."

Professor W. M. Davis, without speaking definitely of the lapse of time by years, endeavors to give some conception of what these and like estimates of geologic ratios really mean, through a translation of them into terms of a linear scale. Starting with the representation of the Postglacial or Recent period, since the North American ice-sheet was melted away, as two inches, he estimates that the beginning of the Tertiary erosion of the Hudson River gorge through the Highlands would be expressed by a distance of ten feet: that the Triassic reptilian tracks in the sandstone of the Connecticut Valley would be probably 50 feet distant; that the formation of the coal beds of Pennsylvania would be 80 or 100 feet back from the present time; and that the Middle Cambrian trilobites of Braintree, Mass., would be 200, 300 or 400 feet from us.

Having such somewhat definite and agreeing ratios, derived from various data by different investigators, can we secure the factor by which they should be multiplied to yield the approximate duration of geologic epochs, periods, and eras, in years? If on the scale used by Professor Davis we could substitute a certain time for the period since the departure of the ice-sheet, we should thereby at once determine, albeit with some vagueness and acknowledged latitude for probable error, how much time has passed since the Triassic tracks were made, the coal deposited, and the trilobites entombed in the Cambrian slates. Now just

this latest and present division of the geologic record, following the Ice age, is the only one for which geologists find sufficient data to permit direct measurements or estimates of its duration. "The glacial invasion from which New England and other northern countries have lately escaped," remarks Davis, "was prehistoric, and yet it should not be regarded as ancient."

In various localities we are able to measure the present rate of erosion of gorges below waterfalls, and the length of the post-glacial gorge divided by the rate of recession of the falls gives approximately the time since the Ice age. Such measurements of the gorge and Falls of St. Anthony by Professor N. H. Winchell show the length of the Postglacial or Recent period to have been about 8,000 years; and from the surveys of Niagara Falls, Professor G. F. Wright and the present writer believe it to have been 7,000 years, more or less. From the rates of wave-cutting along the sides of Lake Michigan and the consequent accumulation of sand around the south end of the lake, Dr. E. Andrews estimates that the land there became uncovered from its ice-sheet not more than 7,500 years ago. Professor Wright obtains a similar result from the rate of filling of kettle-holes among the gravel knolls and ridges called kames and eskers, and likewise from the erosion of valleys by streams tributary to Lake Erie; and Professor B. K. Emerson, from the rate of deposition of modified drift in the Connecticut Valley at Northampton, Mass., thinks that the time since the Glacial period cannot exceed 10,000 years. An equally small estimate is also indicated by the studies ofGilbert and Russell for the time since the highest rise of the Quaternary lakes Bonneville and Lahontan, lying in Utah and Nevada, within the arid Great Basin of interior drainage, which are believed to have been contemporaneous with the great extension of ice-sheets upon the northern part of our continent.

Professor James Geikie maintains that the use of paleolithic implements had ceased, and that early man in Europe made neolithic (polished) implements, before the recession of the ice-sheet from Scotland, Denmark, and the Scandinavian peninsula; and Prestwich suggests that the dawn of civilization in Egypt, China, and India, may have been coeval with the glaciation of northwestern Europe. In Wales and Yorkshire the amount of denudation of limestone rocks on which boulders lie has been regarded by Mr. D. Mackintosh as proof that a period of not more than 6,000 years has elapsed since the boulders were left in their positions. The vertical extent of this denudation, averaging about six inches, is nearly the same with that observed in

the southwest part of the Province of Quebec by Sir William Logan and Dr. Robert Bell, where veins of quartz marked with glacial striæ stand out to various heights not exceeding one foot above the weathered surface of the inclosing limestone.

Another indication that the final melting of the ice-sheet upon British America was separated by only a very short interval, geologically speaking, from the present time, is seen in the wonderfully perfect preservation of the glacial striation and polishing on the surfaces of the more enduring rocks. Of their character in one noteworthy district, Dr. Bell writes as follows:—"On Portland promontory on the east coast of Hudson's Bay, in latitude 58 deg. and southward, the high rocky hills are completely glaciated and bare. The striæ are as fresh-looking as if the ice had left them only yesterday. When the Sun bursts upon these hills after they have been wet by the rain, they glitter and shine like the tinned roofs of the city of Montreal."

From this wide range of concurrent but independent testimonies, we may accept it as practically demonstrated that the ice-sheets disappeared from North America and Europe some 6,000 to 10,000 years ago. But having thus found the value of one term in our ratios of geologic time divisions, we may know them all approximately by its substitution. The two inches assumed to represent the postglacial portion of the Quaternary era may be called 8,000 years; then according to the proportional estimates by Davis, the Triassic period was probably 2,400,000 years ago; the time since the Carboniferous period, in the closing part of the Paleozoic era, has been about four or five millions of years; and since the middle of the Cambrian period, twice or perhaps four times as long. Continuing this series still farther back, the earliest Cambrian fossils may be 20 or 25 millions of years old, and the beginning of life on our Earth was not improbably twice as long ago.

Seeking to substitute our measure of postglacial time in Dana's ratios, we are met by the difficulty of ascertaining first its proportion to the preceding Glacial period, and then the ratio which these two together bear to the Tertiary era. It would fill a very large volume to rehearse all the diverse opinions current among glacialists concerning the history of the Ice age, its wonderful climatic vicissitudes, and the upward and downward movements of the lands which are covered with the glacial drift. Many eminent glacialists, as James Geikie, Wahnschaffe, Penck, DeGeer, Chamberlin, Salisbury, Leverett, Shaler, McGee, and others, believe that the Ice age was complex having two, three,

or more epochs of glaciation, divided by long interglacial epochs of mild and temperate climate when the ice-sheets were entirely or mainly melted away. The astronomic theory of Croll attributes the accumulation of ice-sheets to recurrent cycles which bring the Earth alternately into aphelion and perihelion each 21,000 years during the periods of maximum eccentricity of the Earth's orbit. Its last period of this kind was from about 240,000 to 80,000 years ago, allowing room for seven or eight such cycles and alternations of glacial and interglacial conditions. The supposed evidence of interglacial epochs therefore gave to this theory a wide credence; but the more recent determinations of the geologic brevity of time since the ice-sheets disappeared from North America and Europe make it clear, in the opinions of some of the geologists who believe in a series of Quaternary glacial epochs, that not astronomic but geographic causes produced the Ice age.

Glacialists who reject Croll's ingenious and brilliant theory mostly appeal to great preglacial altitude of the land as the chief cause of the ice accumulation, through either its direct or indirect climatic results, citing as proof of such altitude the fjords and submarine valleys which on the shores of Scandinavia, and the Atlantic, Arctic, and Pacific coasts of North America, descend from 1,000 to 3,000 and even 4,000 feet below the sea level, testifying of former uplifts of these continental areas so much above their present heights. But beneath the enormous weight of their ice-sheets these lands finally sank, so that when the ice in many parts of its extent attained its maximum area and thickness, and during its departure, the areas on which it lay were depressed somewhat lower than now and have since been re-elevated. This view to account for the observed records of the Glacial period has been held by Dana, LeConte, Wright, Jamieson, and others, including the present writer. It is believed to be consistent either with the doctrine of two or more glacial epochs during the Quaternary era, or with the reference of all the glacial drift to a single glacial epoch, which is thought by Wright, Prestwich, Lamplugh, Falsan, Holst, myself, and others, to be more probable. The duration of the Ice age, if there was only one epoch of glaciation, with moderate temporary retreats and readvances of the ice-border sufficient to allow stratified beds with the remains of animals and plants to be intercalated between accumulations of till, may only have comprised a few tens or scores of thousands of years.

From various estimates of the relative ages of different portions of the drift sheets, we have the probable length of Glacial

and Postglacial time together 50,000 or 100,000 years, more or less; but a probably long preceding time, while the areas that became covered by ice were being uplifted to high altitudes, may perhaps with good reason be also included in the Quaternary era, which then would comprise some 150,000 years. Comparing the Tertiary era with the Quaternary, however, I cannot agree with Professor Dana's estimate that the latter was a third as long as the former, and am quite at a loss to discern evidences justifying that view. The best means for learning their ratio I think to be found in the changes of faunas and floras since the beginning of the Tertiary era, using especially the marine molluscan faunas as most valuable for this comparison. Scarcely any species of marine mollusks have become extinct or undergone important changes during the Glacial and Recent periods, but since the Eocene dawn of the Tertiary nearly all of these species have come into existence. Judged upon this basis, the Tertiary era seems at least thirty or forty times longer than the Ice age and subsequent time; in other words, it may well have lasted two millions or even four millions of years. Taking the mean of these numbers, or three million years, for Cenozoic time, or the Quaternary and Tertiary ages together, we have precisely the value of Professor Dana's ratios which he himself assumed for conjectural illustration, namely, 48,000,000 years since the Cambrian period began. But the diversified types of animal life in the earliest Cambrian faunas surely imply a long antecedent time for their development, on the assumption that the Creator worked then as during the subsequent ages in the evolution of all living creatures. According to these ratios, therefore, the time needed for the deposition of the Earth's stratified rocks and the unfolding of its plant and animal life must be about a hundred millions of years.

Reviewing the several results of our different geologic estimates and ratios supplied by Wallace, Haughton, Dana, the Winchells, Davis, and others, we are much impressed and convinced of their approximate truth by their somewhat good agreement among themselves, which seems as close as the nature of the problem would lead us to expect, and by their all coming within the limit of 100,000,000 years which Sir William Thomson estimated on physical grounds. This limit of probable geologic duration seems therefore fully worthy to take the place of the once almost unlimited assumptions of geologists and writers on the evolution of life, that the time at their disposal has been practically infinite.

The foregoing arguments, computations, and estimates, yield-

ing about a hundred million years for the age of the Earth so far as it is known through the observations of geology, seem to me mostly acceptable and true, although the more exact knowledge of astronomy, physics, and chemistry, attained during the past century, shows that the nebular theory formulated by Laplace needs great modifications, being partially superseded by the meteoritic hypothesis of Lockyer and Darwin and by the planetesimal theory of Chamberlin.

Instead of an originally gaseous and very hot condition of the parent nebula, as supposed by Laplace, it appears far more probable that the nebula in its earliest definable state consisted of meteorites, that is, particles and little masses of solid and cold matter. Sir Norman Lockyer, reasoning from his extensive investigations in spectrum analyses, presents this view as follows: "Nebulæ are really swarms of meteorites or meteoritic dust in the celestial spaces. The meteorites are sparse, and the collisions among them bring about a rise of temperature sufficient to render luminous some of their chief constituents."

Besides the testimony of the spectroscope concerning the characters of the nebulæ, we may consider the rings of Saturn, which are very thin but have great areal extent, as probably a strong evidence of the meteoritic derivation of the planets and the Sun. Richard A. Proctor, after stating the physical impossibilities of the existence and permanence of these unique rings as either solid or liquid continuous bodies, wrote: "The sole hypothesis remains that the rings are composed of flights of disconnected satellites, so small and so closely packed that, at the immense distance to which Saturn is removed, they appear to form a continuous mass." In other words, the Saturnian rings are made up of myriads of separately moving small masses, which are doubtless similar to the stony meteorites that fall rarely on the Earth.

Again, the origin of the hundreds of asteroids, or minor planets, mostly no more than a few miles in diameter, but including several from 100 to perhaps about 300 miles in diameter, seems very readily explained under this modification of the nebular theory.

Professor Young well says: "The *meteoric* theory of a nebula does not in the least invalidate, or even to any great extent modify, the reasoning of Laplace in respect to the development of suns and systems from a *gaseous* nebula. The old hypothesis has no quarrel with the new."

Another theory, which differs more widely from the Laplacian hypothesis, has been very recently proposed by Professor T. C.

Chamberlin, of the University of Chicago, who names it the Planetesimal Hypothesis. His studies in this direction have been in progress about five years, with publication of preliminary papers, preparing the way for the new hypothesis; but its first somewhat detailed statement in print appeared only about a year ago.* Since the beginning of the present year, this new theory has been very amply set forth in a geological text-book, with illustrative diagrams.† It is a more applicable nebular theory, especially having in view the origin of the Earth; and it will certainly introduce into geology and geophysics many new and fruitful methods of observation and research. Indeed, nearly all the great fields of theoretical geology now require renewed investigation, by which the planetesimal hypothesis shall be tested.

Chamberlin, in this grand philosophic study, contributes greatly to the establishment of an acceptable nebular theory, consistent with the known relations of the planets, their satellites, and the Sun, by his derivation of the solar system from a spiral nebula, and by his indicating the probable mode of origin of such nebulæ, which abound by tens of thousands throughout the starry heavens, as discovered by the most powerful telescopes.

Both the meteoritic and the planetesimal hypotheses seem to me probably true in their regarding the nebulous matter from which planets and suns are made as having become mostly solid, though finely divided, and as very cold, being in almost absolutely cold and immensely extended space, previous to the condensation and aggregation which formed it into worlds and stars. During the accumulation of the planets and their satellites, much or perhaps nearly all the nebulous matter forming them had remained, until thus gathered as great bodies, apparently in solid and cold molecules or in small masses brought together by their gravitative attraction, as seems reliably evidenced by the rings of Saturn and by the many little asteroids.

Coming to the question whether the accumulation of so large a body as the Earth by the infalling of small and large planetesi-

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* "Fundamental Problems of Geology," in Year Book No. 3, for 1904, of the Carnegie Institution of Washington, published in January, 1905, pp. 195-258.

† Geology. By Thomas C. Chamberlin and Rollin D. Salisbury. In Three Volumes. (New York, Henry Holt and Co.) Vol. I, Geologic Processes and their Results, 1904; pp. xix, 654. Vols. II and III, Earth History, 1906; pp. xxvi, 692, and xi, 624. The Planetesimal Hypothesis is the chief theme of Chapter I, pages 1-81, in Volume II; and discussions of "The Hypothetical Stages leading up to the Known Eras," in Earth History, form Chapter II, pages 82-132, in the same volume.

mal bodies could take place without its becoming intensely hot and molten, somewhat like the Sun, we have first the observations and theories of geology to aid in giving an answer, and these may be advantageously supplemented by the physiographic features of our satellite, the Moon. It has been long held by geologists that the downward increase of heat in the Earth's crust, present volcanoes, the widely distributed evidences of ancient volcanic action, and thermal metamorphism of great rock formations, indicate an internal temperature which must fuse any known rocks, unless they are prevented from this by overlying pressure. The new hypothesis of Chamberlin accounts for vulcanism, and for all that we know of the Earth's internal heat, fully as well as the Laplacian hypothesis of condensation of an intensely hot gaseous nebula, while it better accords with the physical and dynamic relations of the planets and Sun.

When our inquiry is turned to the Moon, we see a most wonderful record, as it is generally regarded, of extinct volcanic action, implying a formerly very hot and probably almost wholly molten state of that globe, which has a little more than one-fourth the diameter of the Earth. Under the planetesimal hypothesis, these two companion globes were doubtless accumulated similarly. The Moon, after acquiring its present size, had multitudes of volcanoes which left round craters, or parts of their crater rims, of varying dimensions from those at the limit of telescopic vision up to one with a diameter of about 800 miles, or nearly four-fifths of the Moon's radius. So great a lake or sea of molten rock, similar to the calderas of Hawaiian volcanoes, but of vastly larger area, whose crater rim is partially preserved in the lunar Carpathian-Apennine-Caucasus chain of mountains, could only exist when much of the interior of the Moon was melted. It seems possible and indeed probable, therefore, that the Earth, whether formed as supposed by the old or the new nebular hypothesis, was nearly or quite all melted during a considerable part of the time of its accumulation. The planets undoubtedly tended in some degree toward the same intensely hot condition which is reached by the Sun and stars in the concentration of originally nebulous matter.

If we accept the planetesimal theory of the formation of the Earth and Moon, we must suppose that nearly all the ingathering of the formerly scattered material had been accomplished before the deposition of the Earth's Paleozoic sediments, else they would here and there reveal evidences of collision of some of the previously planetesimal masses. Geologic antiquity, as

hitherto studied, falls far short of reaching back to the time of completion of the creation of these companion globes, the Earth and its satellite, in nearly the same size and conditions which they have now. But in the new views opened by the planetesimal hypothesis the range of geologic inquiries and theories is extended almost inconceivably farther back, through the laying of "the foundation of the Earth."

St. Paul, Minn.

NEW LIGHT FROM OLD RECORDS.

KURT LAVES.

FOR POPULAR ASTRONOMY.

Our knowledge of Babylonian Astronomy and Babylonian mode of calendar keeping has until recently been extremely limited and inaccurate. Beyond the fact that the Babylonians watched the stars and planets with great care and that they were familiar with the Saros-cycle our average textbooks on astronomy had very little to add. But it is not known to very many that during the last twenty years great strides have been made in this province of learning, and that modern authors who write on General Astronomy will do well not to dismiss this interesting chapter with a few words as heretofore. The student who wants to inform himself adequately along these lines will find a wealth of information contained in the eighteen volumes of the *Assyriologische Zeitschrift* to which many authors on Assyriology and Calendorography have contributed. He will do well to peruse with attention the articles written by Epping and Strassmayer, to whom in the first place is due the credit for a new understanding of the astronomy of those very remote ages. Furthermore he is invited to read the conclusions which Eduard Mahler has been able to arrive at starting as he did from the foundations established on the one side by Epping and on the other side by the world famous school of chronology of von Oppolzer.

When Manetho the Greek historian of Egypt reported his extended list of Egyptian rulers and remote dynasties, he was in his days not less than in the centuries that followed, held up to ridicule till the nineteenth century broke the ban imposed on his work and revealed not only that his lists in the main were correct, nay, that they legitimately could be extended quite a long way back. Quite similar conditions existed a few decades ago about the truthfulness of historic dates of the Babylonian epoch. The scant sources of information then in

the hands of the scientists were considered most likely as entirely insufficient to throw any light on history. Some of these inscriptions on clay tablets when deciphered read perhaps as follows: *In the evening of the 27th day of Nisannu in the 12th year of the reign of King Nabonassar there occurred this or that.....* Nobody was bold enough in those days to hope that a report of this kind would ever be of any real service to science at large. Yet what Epping and Mahler have done is precisely to bring system and meaning into these ancient reports and show that they read well and intelligently after we have learned how to read them.

The riches of the British Museum have justly become proverbial in our days; in the field of Assyriology they seem even to surpass themselves It appears that the number of scientists who work in this field is entirely inadequate to cope with this mass of material, which has to be deciphered and properly interrelated before it can shed its full light of information.

The crucial question in an inscription of the kind given above is evidently: What is the date of that report expressed in our Christian Era? It is not hard to guess that Nisannu is most likely the name of a month, but which one of a year? What kind of a year was employed? How many months and of how many days each, and finally when did Nabonassar come to the throne? Of course it would be a hopeless task to try to understand one single inscription by itself; by juxtaposition of others and clever combination gradually the first opening will be obtained where we can apply our lever. Slow indeed will the progress be and not always will its course be straight. Information which seemed well founded for years will all of a sudden crumble down under the light of some outside consideration. It is not a mere accident that the men who have distinguished themselves in this work are men who have been experts in Astronomy as well as in Assyriology. Indeed the observation of the heavenly bodies formed a very integral part of the culture of those primeval people whose records we now collect with such assiduity and zeal. These records were bound to record facts about the heavenly bodies and by the combined energy of the linguist and astronomer the door was finally unlocked that barred our vision from a vista of great beauty. Before the historian could be benefitted by these researches it was the astronomer's task to supply the tools with which the linguist could work or rather to add to the number of tools that the linguist had been working with, a new set of vital importance. In that respect Epping's work has

been fundamental indeed. In his memoire on the Astronomy of the Babylonians (*Astronomisches aus Babylon, oder das Wissen der Chaldäer über den gestirnten Himmel, Freiburg 1889*) he reports about the decipherment of three tablets, which reveal important material about the astronomical knowledge of the Chaldeans, (i. e., priest-class of the Babylonians.)

Two of these tablets belong to the collection of the British Museum and one to that of the University of Pennsylvania. We shall obtain an idea of the ingenuity and wisdom of Epping when we say that the technical names encountered on these tablets were wholly unknown to the linguists of his days. How he managed to finally introduce the working hypothesis that the tablets contained ephemerides of the planets or observations of the planets cannot fully be realized by any one not familiar with the peculiarities of the cuneiform inscriptions. Having conceived of the idea first that either ephemerides computed in advance or observations of the planets were before him he tested the further hypothesis that the Babylonians had the knowledge of the periods after which the individual planets approximately come back to their positions among the fixed stars. These periods are for Mercury 46 years, for Venus 8, Mars 79, Jupiter 83 and Saturn 59. A set of observations actually made in a certain year on an individual planet would become a sufficiently accurate ephemeris at the end of its period. One of the tablets of the British Museum (marked Rm 678) contains ephemerides for the planets for the year 236 of the Seleucidal Era. This Era falls into the year 311 B. C., and the year 236 corresponds therefore to the year 76 B. C. Since the period of restitution for Jupiter is 83 years the positions of the planet in the year 236 were therefore the same as those in the year 153 S. E. For this year observations of Jupiter were evidently on record and the tablet contains the transcriptions of these observations for the year in question. It will be interesting to put down a few lines of the record as deciphered by Epping; we give two individual observations, the date for the first is not readable, whilst that one for the second is well preserved: .....*in the evening sky, Jupiter above the eastern star of the twins, at the mouth of the twins, distance six inches. Nisannu in the evening of the 27th, in the evening sky Jupiter above the twins of the shepherd, distance three ells.* After Epping had made out the year of the tablet it was necessary for him to see whether or not the positions of the planets as given thereon would tally with the positions computed from our present tables. He gives the results of his computations at the end of his

paper and it is apparent that the two sets of positions are in comparatively close agreement. The date of the second observation—the 27th of Nisan in the year 236 S. E.—is the 17th of May of the year 76 B. C. The Babylonian year was subdivided into 12 months the names of which we record as follows: *Nisannu, Airu, Simannu, Dûzu, Abu, Ulûlu, Tisrîtu, Arah-sna, Kislimu, Tibîtu, and Adaru.*

The Calendar of the Babylonians was not clearly understood by scientists till Eduard Mahler, then assistant of the Geodetic Survey of Austria, unriddled its mysterious construction and revealed a system of great symmetry and comparative simplicity. It will suffice here to say that two kinds of years were used, a common year of 354 days and a year of intercalation which had a length of 383 or 384 days divided into 13 months. Since it happens that the year of the tablet is a common year we need but consider its beginning and record the length of the individual month. The beginning falls on the twenty-first of April, the average length of the month was 29.5 days. In the average length of the month we recognize the synodic month, which, as was shown by Mahler, was known to the Babylonians with unusual accuracy. Since the month had to contain an integer number of days, the Babylonians alternated with months of 29 and months of 30 days so that the length of the year was equal to 12 synodic revolutions of the Moon. We are used to the universal custom of beginning the day at midnight, but this was not the usage of the Babylonians. They began the day at 6 p. m. and this custom likewise prevailed among the Hebrews. The reason for this peculiar mode is evidently to be found in the fact that the Babylonians originally obtained the beginning of the months from the light of the new Moon which becomes visible in the evening. After their system of accurate observations had furnished them a very precise determination of the length of the synodic month it proved not to be necessary to have reference at the beginning of each month to the observations of the first light of the Moon.

Mahler, in his book on the Chronology of the Hebrews, points out the custom prevalent among the old Hebrews not to begin their new month until three trustworthy persons had reported to the Synhedra that the new light of the Moon had become visible. It had been remarked that the year 236 S. E. began on the 21st of April, we shall see later that this was not always the case although it will prove to be true that the beginning is to be found between March 28th and April the 24th. This reveals the important fact that the Calendar of the Babylonians has refer-

ence to the solar cycle and is not to be considered as a purely lunar Calendar. In a second paper we hope to devote some further attention to the contents of Epping's book and the observations recorded in it. It will be seen that the accuracy of the Babylonians in recording the positions of the planets with reference to the neighboring stars is unfortunately not sufficient to obtain from them an improvement of our planetary tables. Indeed Epping computes that the observations of spherical distances obtained by the Babylonians will entail an error of about $^1/_6$ of the diameter of the Moon and only observations made at a very remote epoch could become of value to us with respect to our planetary tables.

Whilst the determination of the year to which the tablet belonged presented no difficulties to the investigator, in general this will constitute one of the hardest questions to be answered. It was stated before that Babylonian records register mainly the day of the month and the year of the king. Before we can know the corresponding Christian date it is necessary to have a table of the kings of Babylon and precise statements of the duration of their reigns.* This obtained, every Babylonian date becomes at once intelligible to us. This has been successfully accomplished by Edward Mahler and his Babylonian tables are now almost universally adopted by the historians. These tables lead us as far back as 747 B. C. and they are continued to about 200 B. C. For the time before 747 B. C. no tables are yet available, as far as I have been able to ascertain, but the continuity in the development of the culture of the Chaldeans makes it more than likely that the system of Calendar keeping had been in vogue before the Era of Nabonassar. The modern excavations will most likely give us information about the time before 747 B. C. and in case we should obtain a record of kings similar to that of Ptolemy, the historian will at once be benefitted by it. It had been noticed before Mahler that two different kinds of years were used by the Babylonians but it seems to have been his privilege to point out the order in which common years and "leap years" were alternated.

We have known for a long time that the Chaldeans had the knowledge of the Saros-cycle, that great period of 223 lunations which is equal exactly to nineteen dracontic years (or 18 Julian

* Ptolemy in his canon of the Babylonian kings has recorded this very information, starting with the king Nabonassar of Babylon. It seems to be sufficiently certain that the Babylonian Calendar began when Nabonassar came to the throne and the Era of Nabonassar is equivalent with April 21st, 747 B. C.

years and 10 or 11 days.) By means of it they were able to foretell the order of the eclipses with an accuracy that must truly have inspired the common people with an unbounded awe for the wisdom of the priest class. It was likewise known that the Greek astronomer Meton used for the perfection of the Greek Calendar another mysterious cycle according to which 235 lunations are equal to 19 tropical years. Expressed in days we have these relations:

235 lunations	$= 6939^{d}$	16^{h}	31^{m}
19 tropical years	$= 6939$	14	27
19 Julian "	$= 6936$	18	0

Dividing the number of days for 235 lunations by 19 Meton is said to have obtained a very accurate value for the length of a civil year.

If the Calendar of the Babylonians had rested solely on the period of the Sun, a Calendar with years of equal length should have been the logical outcome. But that this was not the case could be proved by the comparison of Babylonian records. The question then arose in what order did lunar years and intercalated years alternate and it is to the high credit of Mahler that he solved this question in the masterful manner in which he did it. He found that the cycle of nineteen years began with the first year of the reign of Nabonassar in 747 B. C., of these nineteen years there were twelve lunar years of 354 days length and seven years of 384 days length. Sometimes a lunar year has 353 days and an intercalated year 383 days. The characteristic feature of the lunar period is evidently adhered to throughout the entire Babylonian Calendar. The disorder in the length of the months in our own Calendar stands out in bold relief to this lawful and consistent adherence to the original unit of subdivision of time. At first it would seem arbitrary that twelve common years and seven intercalated years (one naturally avoids the term "leap-year" in this case) should be selected. On second consideration one recognizes a very happy solution in this peculiar arrangement. Indeed 19 tropical years being equal to 235 synodic months we ask what integers x and y fulfill the Diaphantic equation:

$12\,x + 13\,y = 235$ (twelve is the number of months in a common, 13 that in an intercalated year). The only positive integers fulfilling this equation are $x = 12$ and $y = 7$ indeed:

$$12 \times 12 + 13 \times 7 = 235.$$

It is well known that the number seven has had a mysterious character among the oriental people, especially the Hebrews. It is not very unlikely that the Babylonian Calendar has had

something to do with it. In fact the old Hebrews copied the Babylonian Calendar, and even the names of the months clearly show Babylonian origin. It is immaterial that at an early period their beginning of the year was changed from the Spring equinox to the Autumnal equinox.

To indicate the sequence of common and intercalated years, we will represent a common year of 354 days by C and an intercalated year by I. Then the period of 19 years is subdivided into two Octoeteris and one Trieteris in the following fashion:

C, C, I, C, C, I, C, I
C, C, I, C, C, I, C, I
C, C, I,

This order was preserved in a very strict fashion in general, but Mahler reports that sometimes an irregularity was encountered in the following way. When some affliction of national character had befallen the people in a year which originally was to be an intercalated year, the Chaldeans would bring this unlucky year shortly to an end by reducing it to the length of a common year. Then one of the subsequent years accordingly had to be lengthened to avoid disorder in the Calendar. It is readily seen that such an occurrence presents no small difficulties to the historian of our days who tries to unravel the records of bygone ages. When Mahler first published his conclusions and the historic tables based upon them he did not find right away the proper support on the part of the Assyriologist. In fact the discussion about the merits of this new system was quite spirited for a time. To judge from the calm and dignified defense of Mahler himself the unbiased mind would involuntarily side with his arguments from the beginning. But it is quite possible to form a check on them and it was the well known scholar of oriental history Professor Eduard Meyer (of Berlin) who suggested it in the following form. In the Almagest of Ptolemy we find the records of three occultations of stars, the dates of which are given both in the Egyptian and Babylonian mode of Calendar keeping. When Ptolemäus collected these dates he gave the Macedonian translation of the Babylonian months and at the same time the equivalent of the dates in the Egyptian form of Chronology. We record here three occultations and shall give the reduction for the first one alone to show in what way a check value is obtained from it for Mahler's system.

1) 5 Appelaios (= Arah-sna) 67 S. E. = $^{27}/_{28}$ Thoth 504 Nab. = 18 Nov. 247 B. C.
2) 14 Dios (= Tisrîtu) 75 S. E. = $^{9}/_{10}$ Thoth 512 Nab. = 29th Oct. 237.

3) 5 Xanticos(Adar)82 S.E.=14 Thybi 519 Nab.=1 March 229. At the end of each line we have given the date in our Christian Era which we are going to show how to compute. The first line we read *in extenso* as follows:

(The occultation of the star took place) on the 5th day of the month Appelaios which is the month Arah-sna of the Babylonians in the 67th year of the Seleucidal Era (311 B. C.) This is in the evening from the 27th to 28th of the Egyptian month Thoth in the 504th year of the Era of Nabonassar. Now the Egyptian Chronology is quite well understood since Brandes' epoch-making researches (1874) and we know indeed that $^{27}/_{28}$ Thoth 504 Nab. is the 18th of November in the year 247. We must show therefore that under Mahler's interpretation of the Babylonian Calendar the same Christian date is the transliteration of five Appelaios 67 S. E. To do this we first find out which year in the cycle of 19 years the year 67 S. E. corresponds to. We have from Strassmayer (Zeitschrift für Assyriologie vol. VII page 203)

1 Nisannu 65 S. E. = April 14th 247 B. C.

The Era of Nabonassar falls on April 21, 747 B. C. This is the beginning of the Babylonian period of 19 years which forms the unit in their Calendar; 23 such periods had almost passed when the Seleucidal period was introduced as a new reference point which in no way changes the *form* of the Calendar; in fact it rejuvenates, so to say, their initial date from which the counting is carried on. Since $65 = 3 \times 19 + 8$ we see that a date in the 65th year of the Seleucidal Era falls into the ninth year in the new 19 year cycle, that is into the first year of the second Octoeteris of the new period of 19 years. But we had seen that the first two years of an Octoeteris are common years; the first contains 354 days, the second has 355 days, their sum is therefore 709 days. To obtain the Christian date corresponding to the Nisannu 245 B. C. we subtract 709 from 731 which is the sum of the days in the two Julian years and see that the Nisannu 245 is 22 days before the 14th of April, i. e. the beginning of the Babylonian year (67 S. E.) falls on the 23rd of March of the year 245 B. C. This year is an intercalated year of 384 days and at that time the additional month was put in after the sixth month the name of which is Ulûlu. The additional month was simply called the second Ulûlu of that year. Since the Babylonian date to be determined is the 5th Arashna 67 S. E. we see from the order of the months given before that eight months and five days have passed between the beginning of the year and our date. Thus

we obtain its Christian equivalent to be 247 B. C., Nov. 18th. By this proceeding Professor Meyer proved that Mahler's interpretation of the Babylonian Calendar gives us in this case the right answer. The other two occultations he treats in a similar fashion and finds that except for a difference of one day in one of the dates the argument is likewise perfect.

When Professor Meyer published his results Mahler's extended tables were not yet published and on that account the transformation became somewhat lengthy. At present with Mahler's tables before us it is but a matter of a few minutes to pick out the Christian date which corresponds to a given Babylonian date. At the end of the paper is given a reprint from Mahler's tables to make clear how simple indeed is now the work left to the historian. It appeared not to be uninteresting to record the original check work of Professor Meyer in order to initiate the reader into the difficulties encountered from the outset.

There can be no doubt that Mahler's interpretation of the Calendar of the Babylonians may in the future suffer some slight changes, but it seems certain that in the main Mahler has hit on the correct solution of the problem. The great importance which the dates recorded in the Almagest have had in this connection will appear evident from what has been said before.

Astronomical observations when recorded in a scientific way, will always have the final decision in a matter of this kind. It is rather unfortunate that so few records of eclipses are available to decide about the Babylonian Calendar, and that those which we have cannot be considered decisive. Professor C. F. Lehmann in his contributions to Professor Ginzel's *Specieller Kanon* investigates all the material available in this connection but considers that all of them are so inaccurate as to place of observation, phase and other circumstances of importance that no definite results can be derived from them. Ptolemy has recorded a number of *Lunar* eclipses in his Almagest, the dates of which fall between 721 and 382 B. C. Oppolzer has determined the corresponding Christian date of all of them and although there may be some uncertainty in this determination a certain fact remains as a rather strong proof for the accuracy of Mahler's tables: When we start from Oppolzer's Christian dates and use Mahler's tables to obtain the equivalent Babylonian date, all of the ten eclipses fall precisely into the middle of the proper Babylonian month. The way the Babylonian Calendar was arranged namely that the first of each month falls on new Moon, brings indeed the full moon into the middle of each month.

It was stated before that the Greek Astronomer Meton had introduced the cycle of nineteen years into the Greek Calendar and had thus succeeded in keeping it in satisfactory relation to the position of the Sun. It was the year 432 when the new Calendar was introduced. In the IXth volume of the Zeitschrift für Assyriologie Mahler calls attention to the fact that Meton's cycle shows evidence of having been skilfully framed after the model of the Babylonian. It shows the two octoeteris arrangement with only this difference that whilst the Babylonian Octoeteris is

C, C, I, C, C, I, C, I the octoeteris of Meton is
C, C, I, C, I, C, C, I.

But this change is rather a necessary one. Indeed the year 432 is the XIIth year in the Babylonian Cycle of nineteen years, to avoid a difference between his new calendar and the Babylonian he made his selection so that his first year would correspond to the 12th of the Babylonian (which is a common year) and the subsequent years would preserve the character of the years in the Babylonian cycle that come after the twelfth.

The following table shows this more plainly:

Year in Meton's Cycle		Year in the Babyl. Cycle
C	1	XII
C	2	XIII
I	3	XIV
C	4	XV
I	5	XVI
C	6	XVII
C	7	XVIII
I	8	XIX
C	9	I
C	10	II
I	11	III
C	12	IV
I	13	V
C	14	VI
C	15	VII
I	16	VIII
C	17	IX
C	18	X
I	19	XI

Although there is no precise proof that Meton has copied his Calendar from the Babylonians, the evidence in favor of such an assumption is extremely great. Comparing the ability of the Babylonians and the Greek for observational Astronomy we admit at once the vast superiority of the Babylonian mind over that of the Greek. We shall not err, we feel sure, to assign to the Babylonians the masterful construction of the Calendar based upon

the nineteen years period. Morever we know that another people has surely borrowed from the Babylonians the peculiar lunisolar Calendar of which we have been speaking. Indeed the old Hebrew Calendar was precisely of Babylonian character. Even the names of the months were of Babylonian origin. The only point of difference consists in the Hebrews beginning the religious year six months after the beginning of the Babylonian year, whilst their civil year starts on the first of Nisannu. Most likely the Jewish people were forced by their political relations with the Babylonians to adopt the same beginning for their political year. Mahler, who is an expert in the Hebrew Calendar as well, has constructed tables for the Jewish Calendar, which will prove to be very useful to the historian. His attempt to locate historically the dates of certain political or religious events mentioned in the Scriptures, which were said to be accompanied by certain natural phenomena of astronomical character, proves rather interesting reading. It will have to be seen yet, how much confidence can be bestowed on reasoning of this kind, which so largely depends upon clever manipulation of linguistic elements.

Year of Reign	Year of the Nineteen Year Cycle	Nisannu	Airu	Simannu	Dâzu	Abu	Ulûlu	Ulûlu II	Tisritu	Arah-Samna	Kislimu	Tebîtu	Sabâtu	Adaru	Adaru II
1	I	747 IV 21	V 21	VI 19	VII 19	VIII 17	Nabon IX 16	a —	s s a r X 15	XI 14	XII 14	746 I 13	II 11	III 13	—
2	II	746 IV 11	V 11	VI 9	VII 9	VIII 7	IX 6	—	X 5	XI 4	XII 3	745 I 2	I 31	III 1	—
3	III	745 III 30	IV 29	V 28	VI 27	VIII 26	VIII 25	—	IX 23	X 23	XI 21	XII 13	I 19	II 18	III 20
4	IV	744 IV 18	V 18	VI 16	VII 16	VIII 14	IX 13	—	X 12	XI 11	XII 10	743 I 9	II 7	III 9	—

In explanation of these tables we are going to solve the following problem:

What Christian date corresponds to the 12 Kislimu of the year 2 of King Nabonassar?

Solution: We enter Mahler's tables, of which the foregoing tabular lines are a reprint for the first four years of Nabonassar. In the first column we take the second line and follow it up till we come to the month Kislimu. We find that the first of this month is equivalent to the 3 December 746 B. C. Therefore will the 12 Kislimu of the year 2 of Nabonassar be equal to 746 December 15th B. C.

The University of Chicago.
1906 March 8th.

GIVEN THE ELEMENTS OF AN ASTEROID, TO COMPUTE, DIFFERENTIALLY, ITS DAILY MOTION IN GEOCENTRIC RIGHT ASCENSION.

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[Communicated by Rear-Admiral C. M. Chester, U. S. N., Superintendent.]

FOR POPULAR ASTRONOMY.

It may now and then happen that the astronomer requires an accurate knowledge of the daily motion of an asteroid in right ascension for some particular date, having available no data other than the orbital elements. Such a necessity recently arose with the writer under somewhat exceptional circumstances, which called for the exact motion of an asteroid in R. A. during an hour or two of time. Of course, the required motion could be found by computing from the given elements the exact right ascension of the object for two or three consecutive days, or hours, which would embrace the assigned date. But this method would require the use of six or seven place logarithms throughout the computation, and thus would appear to be unduly laborious in view of the nature of the result. Formulæ were therefore written out which give the result differentially; and since their application requires only four-figure logarithms, considerable labor is thereby saved in the numerical work. Believing that these formulæ may prove useful in the form given below, the writer submits them with an example illustrating their use.

Let the orbital elements be given as follows:

M_0 = The mean anomaly at the epoch t_0;
Ω = longitude of node, } referred to the mean
ω = node to perihelion, } equinox of Jan. 0 of the
i = the inclination, } year T_0; *
ϕ = $\sin^{-1} e$, where e = the eccentricity;
a = the mean distance;
μ = the mean daily motion, in seconds of arc.

* When T_0 is a leap year, Jan. 1 should be substituted for Jan. 0. This applies to similar references made hereafter.

Let t denote the time for which the daily motion in R. A. is required; and T the year in which this date falls. If we now put, for the time t,

M = the mean anomaly,
E = the eccentric anomaly,
v = the true anomaly,
u = the argument of the latitude,

we have the formulæ—

$$\left.\begin{aligned} M &= M_0 + \mu\,(t - t_0) \\ E &= M + \sin\phi \sin E \\ r &= a\,(1 - \sin\phi \cos E) \\ \gamma &= 45^\circ + \frac{\phi}{2} \\ \tan\frac{v}{2} &= \tan\gamma \tan\frac{E}{2} \\ u &= \omega + v \\ \sin b &= \sin i \sin u \\ \tan(l - \Omega) &= \cos i \tan u \\ x &= r \cos b \cos l \\ y_1 &= r \cos b \sin l \cos\epsilon \\ y_2 &= r \sin b \sin\epsilon \\ y &= y_1 - y_2 \end{aligned}\right\} \qquad (1)$$

where ϵ is the mean obliquity of the ecliptic, and x and y are heliocentric rectangular coördinates of the asteroid, referred to the mean equator. The x axis is directed toward the mean vernal equinox of Jan. 0 of the year T_0; the y axis, perpendicular thereto, lies also in the plane of the equator.

From any of the leading ephemerides we may take—

X, Y, the geocentric equatorial rectangular coördinates of the Sun, referred to the mean equinox of Jan. 0 of the year T. Strictly speaking, however, we require the coördinates X_0 and Y_0, which are referred to the same equinox as the coördinates x and y,—*i.e.* the mean equinox of the beginning of the year T_0. Simple expressions for the corrections enabling us to pass from X and Y to X_0 and Y_0 will be given later on.

Now we have

$$\Delta \cos\delta \cos\alpha = X_0 + x$$
$$\Delta \cos\delta \sin\alpha = Y_0 + y$$

and therefore

$$\tan\alpha = \frac{Y_0 + y}{X_0 + x} \qquad (2)$$

Having collected the formulæ which determine α, we proceed to write out the differential expressions which will give the value of $d\alpha$, the required daily motion in R. A. From the first three of the equations (1) we derive (the unit of time being the mean solar day)

$$dM = \mu \sin 1''$$

$$dM = dE\,(1 - \sin\phi \cos E) = \frac{r}{a}\,dE$$

$$dr = a \sin\phi \sin E\, dE = a \sin\phi \sin E \left(\frac{a}{r}\right) \mu \sin 1''$$

whence, denoting $\frac{dr}{r}$ by $d\rho$, we have

$$d\rho = \frac{dr}{r} = \left(\frac{a}{r}\right)^2 \mu \sin 1'' \sin\phi \sin E \qquad (3)$$

the factor sin 1″ being introduced in order that the differential quantities throughout the development may be expressed in circular measure.

From Watson's Theoretical Astronomy (page 57) we have, directly,

$$dv = \sqrt{1 - e^2}\left(\frac{a}{r}\right)^2 dM = \left(\frac{a}{r}\right)^2 \mu \cos\phi \sin 1''$$

Again, we obtain from (1), by differentiation,

$$du = dv = \left(\frac{a}{r}\right)^2 \mu \cos\phi \sin 1'' \qquad (4)$$

$$db = \sin i \sec b \cos u\, du \qquad (5)$$

also

$$\sec^2 (l - \Omega)\, dl = \cos i \sec^2 u\, du$$

or, since $\cos b \cos (l - \Omega) = \cos u$,

$$dl = \cos i \sec^2 b\, du \qquad (6)$$

By differentiating the logarithms of x, y_1, and y_2, and noting that $d\rho = \frac{dr}{r}$, we get

$$\left.\begin{aligned} dx &= x\,(d\rho - \tan b\, db - \tan l\, dl) \\ dy &= dy_1 - dy_2 \\ &= y\, d\rho - y_1 \tan b\, db - y_2 \cot b\, db + x \cos\epsilon\, dl \end{aligned}\right\} \qquad (7)$$

Finally, from (2), by logarithmic differentiation and reduction,

$$d\alpha \text{ (in radians)} = \tfrac{1}{2} \sin 2\alpha \left[\frac{dY_0 + dy}{Y_0 + y} - \frac{dX_0 + dx}{X_0 + x}\right] \qquad (8)$$

Let us now put

$$\left.\begin{aligned} m &= \sin\phi \sin E \\ h &= \sin\phi \cos E \\ \lambda &= \frac{r}{a} = 1 - h \\ k &= 10^5 \sin 1'' \left(\frac{\mu}{\lambda^2}\right) \end{aligned}\right\} \qquad (9)$$

It then follows from (3) and (4) that the values of $d\rho$ and du will be expressed in circular measure, *in units of the fifth place of decimals*,* by the formulae—

$$d\rho = km, \quad du = k \cos\phi \qquad (10)$$

*This unit is arbitrarily chosen, merely as a convenience in computation.

Accordingly, if the values given by (10) are employed in the computation of db, dl, dx and dy, as defined by (5), (6) and (7), we shall have dx and dy expressed in radians, *in units of the fifth decimal.*

Finally, then, if dX_0 and dY_0 in equation (8) be now defined specifically as the daily variations of X_0 and Y_0, *expressed in units of the fifth decimal*, we shall obtain the required value of $d\alpha$ *in seconds of time* from the formula—

$$d\alpha = \frac{10^{-5}}{2}\left(\frac{1}{15}\csc 1''\right)\sin 2\alpha\left[\frac{dY_0 + dy}{Y_0 + y} - \frac{dX_0 + dx}{X_0 + x}\right] \quad (11)$$

Approximate formulæ giving the corrections to be applied to X and Y in order to obtain X_0 and Y_0 are readily derived as follows:

From the American Ephemeris for 1906, page 585, we have

$$X = R\cos\lambda$$
$$Y = R\sin\lambda\cos\epsilon + (\text{a small term in } \beta)$$

where β is the Sun's latitude. Now, to consider the effect of passing from the mean equinox of Jan. 0, year T, to that of Jan. 0 of the year T_0, we may, for our present purpose, safely neglect the small term in Y, also the slight annual variation in the obliquity (ϵ), and consider the Sun's longitude (λ) as the only variable. Thus, by differentiation, we get

$$\begin{aligned} X_0 - X = \Delta X &= -R\sin\lambda\,\Delta\lambda \\ &= -Y\sec\epsilon\,\Delta\lambda = -Y\sec\epsilon\,(\lambda_0 - \lambda)\sin 1'' \\ Y_0 - Y = \Delta Y &= +R\cos\lambda\cos\epsilon\,\Delta\lambda = +X\cos\epsilon\,\Delta\lambda \\ &= +X\cos\epsilon\,(\lambda_0 - \lambda)\sin 1'' \end{aligned}$$

λ_0 being the Sun's longitude referred to the mean equinox of the beginning of the year T_0. Since the annual precession in longitude is about $+ 50''.26$, we shall have

$$\lambda_0 - \lambda = +50''.26\,(T_0 - T) = -50''.26\,(T - T_0)$$

Therefore the above expressions for ΔX and ΔY become, *in units of the seventh decimal,*

$$\left.\begin{aligned} X_0 - X &= +50.26\sin 1''\sec\epsilon.(10^7)\,(T - T_0)\,Y \\ Y_0 - Y &= -50.26\sin 1''\cos\epsilon.(10^7)\,(T - T_0)\,X \end{aligned}\right\} \quad (12)$$

We now collect from equations (1), (2), (5), (6), (7), (9), (10), (11), and (12), such formulæ as are necessary for our purpose, substituting therein the numerical values of all the constant coefficients. Thus, noting that $\epsilon = 23^\circ\,27'$, we obtain the following formulæ, in which the numbers within brackets are common logarithms:

t = the date for which $d\alpha$ is required,
M_0 = the mean anomaly at the epoch t_0,
Ω, ω, i = elements referred to the mean equinox of Jan. 0 of the year T_0,

T = the year in which the date t falls,

X, Y = ephemeris values of the Sun's equatorial rectangular coördinates (for the time t), referred to the mean equinox of Jan. 0 of the year T,

X_0, Y_0 = the corresponding coördinates (for the time t), referred to the mean equinox of Jan. 0 of the year T_0,

$$\left.\begin{aligned} X_0 &= X + 2657\ Y(T - T_0) \\ Y_0 &= Y - 2236\ X(T - T_0) \end{aligned}\right\}$$ where the numerical coefficients are in units of the seventh decimal.

(The interval $T - T_0$ must be expressed in years.)

Find X_0 and Y_0 for three or four consecutive days, and thence by differences obtain—

dX_0, dY_0 = the daily variations of X_0 and Y_0, for the time t, *expressed in units of the fifth decimal.*

Now proceed as follows:

$$M = M_0 + \mu\,(t - t_0)$$
$$E - M = \sin\phi \sin E \csc 1' = [3.5363] \sin\phi \sin E$$

in which $t - t_0$ must be expressed in mean solar days, and $E - M$ in minutes of arc.

Find E by trial from the last equation: then compute—

$$h = \sin\phi \cos E, \qquad m = \sin\phi \sin E$$
$$m' \text{ (in minutes of arc)} = m \csc 1' = [3.5363]\ m$$
$$E = M + m' \quad (\textit{as a check})$$
$$\lambda = 1 - h, \quad r = a\lambda$$
$$k = [9.6856]\ \frac{\mu}{\lambda^2} \quad (\text{express } \mu \text{ in seconds of arc.})$$
$$\gamma = 45^\circ + \frac{\phi}{2}, \quad \tan\frac{v}{2} = \tan\gamma \tan\frac{E}{2}$$
$$u = \omega + v$$
$$\sin b = \sin i \sin u \quad (\text{take } b \text{ between the limits } + 90^\circ \text{ and } - 90^\circ.)$$
$$\tan(l - \Omega) = \cos i \tan u \qquad (l - \Omega \text{ and } u \text{ lie in the same quadrant.})$$
$$y_1 = [9.9626]\ r \cos b \sin l$$
$$y_2 = [9.5998]\ r \sin b$$
$$x = r \cos b \cos l, \quad y = y_1 - y_2$$
$$d\rho = km, \quad du = k \cos\phi$$
$$db = \sin i \sec b \cos u\ du$$
$$dl = \cos i \sec^2 b\ du$$
$$dx = x\,(d\rho - \tan b\ db - \tan l\ dl)$$
$$dy = y d\rho - y_1 \tan b\ db - y_2 \cot b\ db + [9.9626]\ x dl$$

[These formulæ give dx and dy in units of the fifth place of decimals.]

Next find the quantities—

$$P = dX_0 + dx, \quad Q = dY_0 + dy$$

(See that dX_0 and dY_0 are expressed in units of the *fifth* decimal.)

$$p = X_0 + x, \quad q = Y_0 + y$$
$$\tan\alpha = \frac{q}{p} \quad (\sin\alpha \text{ and } q \text{ have the same sign})$$

where α is the R. A. of the asteroid, referred to the mean equinox of the beginning of the year T_0. Finally, compute

$$d\alpha = [8.8373]\left(\frac{Q}{q} - \frac{P}{p}\right)\sin 2\alpha$$

which is the value of the daily motion in α for the date t, expressed in seconds of time.

Note:— When the interval $T - T_0$ does not exceed four or five years, we may, unless extreme accuracy is demanded, replace X_0, Y_0, dX_0 and dY_0 by X, Y, dX and dY in the foregoing expressions.

As an example of the use of the above formulæ, let it be required to find the daily motion in R. A. of the asteroid (198) Ampella, for the date t = 1903, Dec. 24.0, Berlin mean time.

From the Berliner Astronomisches Jahrbuch for 1905, page 416, we take the following elements:

Epoch, t_0 = 1903, Nov. 25.0, Berlin mean time;

$M_0 = 51°\ 40'$	$\omega = 87°\ 16'$	Mean equinox of 1900.0
$\log a = 0.3907$	$\Omega = 268°\ 28'$	
$\phi = 13°\ 6'\ 49''$	$i = 9°\ 18'\ 45''$	
$\mu = 920''.2$		

From the Berliner Jahrbuch for 1903, page 40, we take out the following values of X and Y, referred to the mean equinox of 1903.0:

Ber. M. T. 1903	X	Y
Dec. 23.5	+ 0.0164529	− 0.9021636
24.0	0.0251962	0.9019679
24.5	0.0339372	0.9017019
25.0	+ 0.0426752	− 0.9013656

Here we have T = 1903, T_0 = 1900, and $T - T_0$ = + 3; thus we get the following corrections to be applied to X and Y:

	ΔX	ΔY	
1903, Dec. 23.5	−7191	−110	in units of the seventh decimal.
24.0	7190	169	
24.5	7188	228	
25.0	−7185	−286	

[These corrections agree substantially with those following X and Y in the Jahrbuch for 1903, owing to the fact that in both cases the reductions refer to the mean equinox of 1900.0]

Thus the values of X_0 and Y_0, referred to the mean equinox of 1900.0, are as follows:

Ber. M. T. 1903	X_0	Δ'	Δ''	Y_0	Δ'	Δ''
Dec. 23.5	+0.0157338			−0.9021746		
		+87434			+1898	
24.0	0.0244772		−22	0.9019848		+703
		87412			2601	
24.5	0.0332184		−29	0.9017247		+704
		+87383			+3305	
25.0	+0.0419567			−0.9013942		

From the differences Δ' and Δ'' we obtain, for t = Dec. 24.0,

$$dX_0 = +\ 874.2 \times 2 = +\ 1748.4$$
$$dY_0 = +\ \ 22.5 \times 2 = +\ \ \ 45.0$$

which are the *daily* variations of X_0 and Y_0, in units of the *fifth* decimal. The computation of $d\alpha$ proceeds as follows:

t	Dec. 24.0
t_0	Nov. 25.0
$t - t_0$	$+\ 29^d.0$
$\mu\,(t - t_0)$	$+\ 26686'' = +\ 7°\ 25'$
M_0	51 40
M	59° 5′
log sin ϕ	9.3558
log const.	3.5363
Sum	2.8921

$\therefore (E - 59°5')$min. of arc $= [2.8921] \sin E$

$\therefore E$(by trial) $= 71°\ 24'$

log cos E	9.5037
log sin ϕ	9.3558
log sin E	9.9767
log h	8 8595
log m	9.3325
log const.	3.5363
log m'	2.8688
m' $739' =$	12° 19′
M	59 5
E (check)	71 24
h	0.0724
λ	0.9276
log λ	9.9674
log a	0.3907
log r	0.3581
log const.	9.6856
log μ	2.9639
colog λ^2	0.0652
log k	2.7147
$\frac{1}{2}\phi$	6° 33′
γ	51 33
$\frac{1}{2}E$	35 42
log tan γ	0.1002
log tan $\frac{E}{2}$	9.8565
log tan $\frac{v}{2}$	9.9567
$\frac{1}{2}v$	42° 9′
v	84 18
ω	87 16
u	171 34
log sin i	9.2090
log sin u	9.1663
log sin b	8.3753
log cos i	9.9942
log tan u	9.1710_n
log tan $(l - \Omega)$	9.1652_n

$l - \Omega$	171° 41′
Ω	268 28
l	80 9
log cos l (1)	9.2332
log cos b (2)	9.9999
log r (3)	0.3581
log sin b (4)	8.3753
log const. (5)	9.5998
log x [(1)+(2)+(3)]	9.5912
log y_2 [(3)+(4)+(5)]	8.3332
log(r cos b) [(2)+(3)]	0.3580
log const.	9.9626
log sin l	9.9936
log y_1	0.3142
y_1	+2 062
y_2	+0.022
y	+2.040
log m	9.3325
log k	2.7147
log cos ϕ	9.9885
log $d\rho$	2.0472
log du	2.7032
log sin i	9.2090
log sec b	0.0001
log cos u	9.9953_n
log db	1.9076_n
log cos i	9.9942
log sec^2 b	0.0002
log du	2 7032
log dl	2.6976
log tan b	8.3754
log db	1.9076_n
log (tan bdb)	0.2830_n
log y_1	0.3142
log (y_1 tan bdb)	0.5972_n
log (cot bdb)	3.5322_n
log y_2	8.3332
log (y_2 cot bdb)	1.8654_n
log tan l	0.7604
log dl	2.6976
log (tan ldl)	3.4580
$d\rho$	+ 111.5
− tan bdb	+ 1.9
− tan ldl	−2871.
$\frac{dx}{x}$	−2758.
log $\left(\frac{dx}{x}\right)$	3.4406_n
log x	9.5912
log dx	3.0318_n

dx	$-1076.$		$\log q$		0.0561
dX_0	$+1748.4$		$\log p$		9.6176
P	$+\ 672.4$		$\tan a$		0.4385
log const.	9.9626		a		69° 59′
$\log x$	9.5912		$2a$		139 58
$\log dl$	2.6976		$\log Q$		2.7228
Sum	2.2514		$\log q$		0.0561
[9.9626] xdl	$+178.4$	(A)	$\log \left(\frac{Q}{q}\right)$		2.6667
$\log y$	0.3096				
$\log d\rho$	2.0472		$\log P$		2.8277
$\log (yd\rho)$	2.3568		$\log p$		9.6176
$yd\rho$	$+227.4$	(B)	$\log \left(\frac{P}{p}\right)$		3.2101
$-y_1 \tan bdb$	$+\ 4.0$	(C)			
$-y_2 \cot bdb$	$+\ 73.4$	(D)	$\frac{Q}{q}$		$+\ 464.2$
dy [=(A)+(B)+(C)+(D)]	$+483.2$		$\frac{P}{p}$		$+16.\ 2.$
dY_0	$+\ 45.0$				
Q	$+528.2$		$\frac{Q}{q} - \frac{P}{p}$		$-1158.$ (N)
X_0	$+0.0245$		log const.		8.8373
x	$+0.3901$		$\log N$		3.0637_n
p	$+0.4146$		log sin $2a$		9.8084
Y_0	-0.902		log da		1.7094_n
y	$+2.040$		$\therefore da$	$= -51''.22$	
q	$+1.138$				

This result differs only 0″.04 from the daily motion derived from the ephemeris of (198) Ampella found on page 478 of the Berliner Jahrbuch for 1905. A very slight discrepancy should be expected, however, inasmuch as the ephemeris gives the *apparent* R. A., referred to the true equator and equinox of date; whereas our computation deals with the *true* (or geometric) R. A., referred to the mean equator and equinox of 1900.0.

OUTLINE OF A LABORATORY COURSE IN ELEMENTARY ASTRONOMY.

MARY E. BYRD.

FOR POPULAR ASTRONOMY.

The equipment for an elementary course in astronomy demands no great outlay of money. The instrumental appliances required are:

1. Altazimuth for measuring angles.
2. Plumb lines and horizontal sun-dial for finding time.
3. Gnomon post for determining latitude.
4. Opera-glasses or small telescope.
5. Celestial globe.
6. Common clock.

Add to these one or more of the small almanacs, a copy of the American Ephemeris for the year, one of the current astronomical publications, and the entire outfit, excepting the celestial globe, need not cost more than fifty dollars.

Large variations in detail are legitimate, both as regards method and material. Five subjects are essential in any scheme. They are:

1. The Constellations.
2. Diurnal Paths of Sun and Moon.
3. Path of Sun, Moon and Planets among the Stars.
4. Latitude and Time.
5. Use of Opera-glasses or small Telescope.

This arrangement of topics is merely one of statement. There can be no fixed order in observing heavenly bodies. Much depends upon the weather, and the phase of the Moon. When it is cloudy or very cold, emphasis is naturally placed upon descriptive astronomy, as given in text-books. Due allowance being made for this part of the subject, and the irregular hours of observing the following list of exercises represents a fair amount of practical work, if the study is taken up in the third or fourth year of the high school course.

1. Become familiar with thirty constellations so as to recognize them readily in different seasons.

2. Make separate sketches of twenty constellations, directly from the sky, including at least five stars in each.

3. Twice in the same evening, allowing an interval of an hour or more, note the position of three bright constellations, one chosen near the eastern horizon, one near the meridian and the third near the horizon toward the west.

4. Orient four of the circumpolar constellations in reference to the North Star, twice in the same evening, allowing an interval of an hour or more.

5. Fix a diurnal path of the Sun by measuring its altitude and azimuth at five different times, including southing and setting.

6. Fix approximately five other diurnal paths of the Sun, at intervals of three weeks or more, by measuring its altitude at noon and azimuth at setting.

7. Fix a diurnal path of the Moon by measuring its altitude and azimuth at five different times, including either rising, southing or setting.

8. Check meridian altitudes from declination, and azimuths at rising or setting from the celestial globe.

9. Plot all diurnal paths on rectangular paper and note the following points:

(1) Changes in noon altitude and sunset point.

(2) Connection between the extent of solar paths and seasons of the year.

(3) Likeness or unlikeness of solar and lunar paths.

(4) Connection between the extent of a path and declination of the body.

10. Note, two or three times, at an interval of a month or more, the zodiacal constellation first seen in the west after sunset.

11. Find out by watching, how soon the Moon is visible after new Moon, where it is first seen, and in what direction the horns point.

12. Find when and where the Moon rises on the night when it is full.

13. A day or two before full Moon, and a day or two after, note which limb is defective.

14. Five or six times in some one lunar month, locate the Moon approximately in a constellation by aligning from bright stars.

15. On one evening, allowing an interval of an hour or more, make two sketches of the Moon in reference to stars near it, by estimating angles and star-lines, in other words, map the Moon among the stars.

16. From data obtained by exercises 14 or 15, fix two positions of the Moon on the celestial globe, and find its daily and hourly motion among the stars.

17. Map one of the bright planets among the stars, on ten evenings at intervals of a few days or a week or two, according to its rate of motion.

18. In like manner, map a second bright planet on five evenings.

19. From data obtained by exercises 16 and 17, plot the paths of the planets observed, on specially prepared star-maps, and note the following points:

(1) In what direction each planet is moving among the stars, and whether the direction of either changes.

(2) How rates of motion of one planet at different times, or both planets at the same time, compare.

(3) How the paths are placed with regard to the ecliptic, and what constellations are traversed in whole or in part.

20. Plot on the celestial globe the positions of a planet for

two dates and find its motion in right ascension and declination for the interval.

21. Observe the transit of the same star twice over the same reference line, so as to find out which is the longer, the sidereal or mean solar day, and by how many minutes the two differ.

22. At sun noon find the error of a watch within a minute,

(1) By the shadow of the gnomon post.

(2) By two plumb lines used as a transit instrument.

23. At any hour of the day, find the error of a watch within a minute from the horizontal sun-dial.

24. Determine the latitude of the place of observation within a degree,

(1) By the gnomon post.

(2) By the Sun's altitude at noon.

(3) By the altitude of the North Star on or off the meridian.

25. Trace the celestial equator and ecliptic in the heavens by the stars near their paths, noting the positions of the equinoxes.

26. Make two sketches about five months apart, showing where the equator and ecliptic intersect the horizon.

27. Locate a north and south line from the noon shadow of a gnomon post.

Opera-Glasses.

28. Determine the magnifying power of an opera-glass, and test it for double field of view, double image, and fringes of light.

29. Examine ten objects with opera-glasses, including planets, star clusters, nebulæ and double stars.

30. Identify seven objects on the Moon with opera-glasses.

Small Telescope.

28. Determine the focal length, field of view, and magnifying power of a small telescope.

29. Examine with a telescope ten objects, including planets, star clusters, nebulæ and double stars.

30. Identify fifteen objects on the Moon.

The note-book record of each student which constitutes an integral part of every exercise should be made according to the following rules:

(1) Begin the record for each evening on a separate page.

(2) At the head of each page name the place of observing, day of the week, day of the month and the year.

(3) Name in connection with every observation any instrument employed, describing it if possible when first used.

(4) Write out notes in such detail that others following them could take the same observation in the same way.

(5) Keep all records of direct observations in pencil, and make, in ink, any corrections necessary.

HAGEN'S ATLAS STELLARUM VARIABILIUM, SERIES V.

PAUL S. YENDELL.

For Popular Astronomy.

This Series, the first to appear of Fr. Hagen's Atlas of the Variable Stars, has just come from the press. With its carefully prepared maps and star-lists, it constitutes one of the most valuable aids that have been given to the observer of variable stars, and is a monument to the thorough and painstaking care and labor expended upon its preparation by Fr. Hagen and his associates.

It consists of twenty-one maps, which show all those stars which have their minimum light above the seventh magnitude, whose variability was certainly known at the time of going to press. Besides the variables, these maps include all the stars that have been used as comparison-stars in observing them, as well as all those naked-eye stars that are conspicuous in their respective neighborhoods, or useful in finding the objects sought.

Corresponding to each map is a list of the stars contained in it, with their Bayer letters and their Flamsteed and DM numbers, their apparent places for 1900, and their magnitudes according to the Potsdam and Harvard Photometric Catalogues, and, in the cases of such stars as are there included, of the Uranometria Argentina. In the last four maps, which show the region near the South Pole, the notation is from Bayer, the Uranometria Argentina and the Southern Meridian Photometry (Pickering), and the magnitudes from the two latter and Roberts' Lovedale Magnitudes. Besides this, the last column of each list is a column of notes, which contains supplementary information as to color, limits of variation, and notations in other catalogues than those named. At the foot of each list is a table of the comparison-stars used by different observers, which includes practically all the stars that have been used for each variable; these tables are most valuable to all who busy themselves with the study of these objects, as they afford the means of comparing one's work with

that of any other whose name is included in the tables. They are especially useful to beginners and generally to those who may take up the observation of any of the stars included, as they save them the trouble of hunting up comparison-stars for themselves.

The fact that the selection of the stars on these maps was made, not by compiling from the catalogues only, but from actual observation around each star, forms in itself a decided addition to their value.

Each map and list is separate, and can be used by itself, which obviates the inconvenience, frequently very considerable, of having to handle the whole volume while observing, or when consulting or comparing maps and lists. The sheets are enclosed in a neat, strong and serviceable portfolio, a very convenient arrangement for working purposes. The whole constitutes an exceedingly valuable contribution to our map-list, and should be on the book-shelves of every observer who busies himself with this line of work.

The mechanical execution of the whole Series is in keeping with the care and labor expended upon its preparation; the printing of title, preface, lists, etc., and the lithography of the maps, are most excellent, the latter being among the best-executed works of the kind that it has ever been our good fortune to see, and bearing well the comparison with those of Heis's well-known Atlas, which the writer has always considered a model.

We congratulate Fr. Hagen and his assistants on the result of their labors and confidently hope that the remaining Series will prove no less satisfactory.

Dorchester, Mass., 1906, March 31.

Atlas Stellarum Variabilium. Series Quinta, Totius caeli stellas variabiles complectens, Quarum lux minima est supra 7M, Composita a J. G. Hagen, S. J., Directore Speculae Universitatis Georgiopolitanae, Washington, D. C., Et typis descripta subsidiis Cl. Domini Catharinae W. Bruce. - - - Berolini, apud Felicem L. Dames, MCMVI.

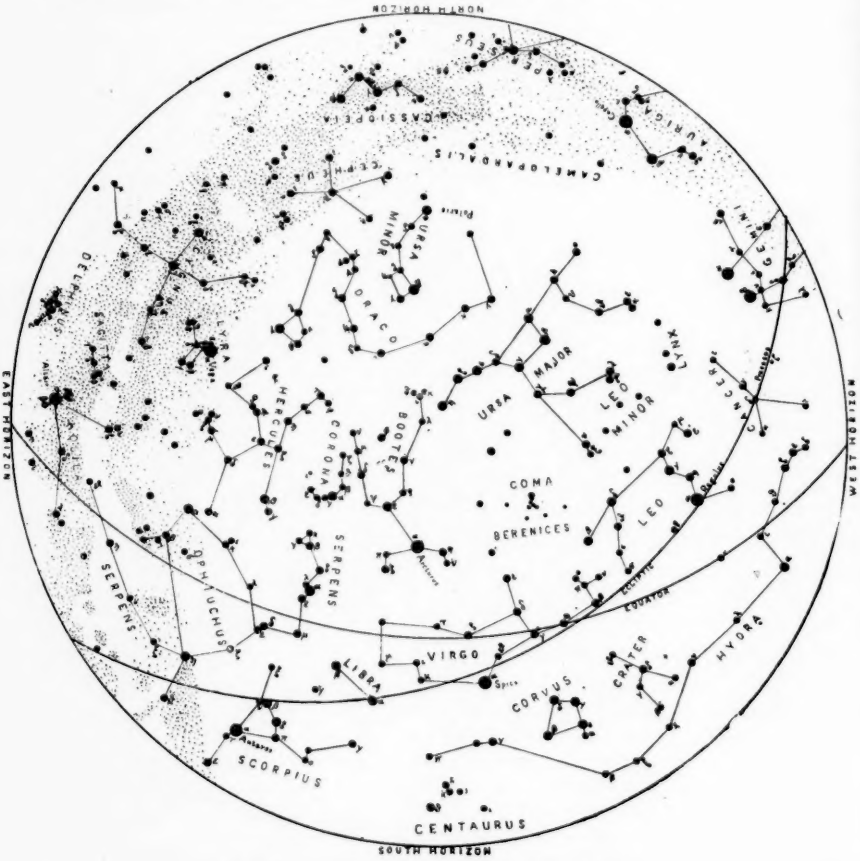
PLANET NOTES FOR JUNE, 1906.

H. C. WILSON.

Mercury will be at superior conjunction June 8, and so will be visible during this month.

Venus is already (April 15) quite a conspicuous object in the west a half hour after sunset. In June she will be visible for two hours after the setting of the Sun and will slowly increase in brightness during the month. The face of Venus is gibbous, diminishing from 0.88 June 1 to 0.81 June 30.

Mars may also be seen in the west as evening star but will be too close to the Sun for observations of any value. On June 15 at 10 o'clock P. M., central standard time, Mars will be in conjunction with Mercury. On June 26 also Mars and Neptune will be in conjunction, both being invisible at that time.



THE CONSTELLATIONS AT 9 P. M. June 1, 1906.

Jupiter will be at superior conjunction June 10, and so will not be observable during the month. Jupiter and Mercury will be in conjunction with each other on the morning of June 9.

Saturn will be at quadrature, 90° west from the Sun, on the morning of June 6, and may be observed toward the southeast a couple of hours on any clear morning. The planet reaches the turning point in its path on June 27, being stationary in right ascension on that date.

Uranus will be at opposition June 28 and so is near its best position for observation for this year. Southern observers may have splendid opportunities for studying the planet, but to northern observers the low declination renders almost useless any attempt at a study of the surface markings. The planet is in Sagittarius near the lowest point of the ecliptic.

Neptune will be at superior conjunction July 2 and so is too near the Sun for observation in June. Neptune will be in conjunction with Venus on June 2, with Mercury June 19 and with Mars June 26.

Occultations Visible at Washington.

Date 1906.	Star's Name	Magnitude.	IMMERSION. Washington M. T.	IMMERSION. Angle f'm N pt.	EMERSION. Washington M.T.	EMERSION. Angle f'm N pt.	Duration.
			h m	°	h m	°	h m.
June 2	65 Virginis	6.0	12 04	169	12 42	238	0 38
7	B.A.C. 6347	5.9	16 37	104	17 38	244	1 01
25	7 Leonis	6.2	8 58	95	9 52	301	0 53
25	ξ^1 Librae	6.5	10 00	59	10 35	334	0 35

COMET AND ASTEROID NOTES.

Comet *c* 1905 observed after Perihelion.—An observation was obtained by Professor H. R. Morgan of Glasgow, Mo., on February 21, 1906, $7^h\ 40^m\ 44^s$ (local time?). The position of the comet was then R. A. $1^h\ 08^m\ 29^s.2$, Decl. — 11° 09′, which is within 5′ of the place indicated by Wedemeyer's ephemeris in A. N. 4074.

Professor Pickering also states in Harvard College Observatory Circular 114 that the comet was observed at Arequipa on February 14, and 17.

Comet *b* 1906 Kopff. A telegram has been received at this Observatory from Professor O. A. Leuschner at Berkeley, California, stating that the following ephemeris of Comet *b*, 1906 (Kopff) has been computed by Messrs. Crawford and Champreux from elements derived from observations of March 5, 15, 27.

EPHEMERIS.

Gr. M. T.		d	R. A. h	m	s	Dec. °	′	Light
1906	April	2.5	11	23	53	+2	21	0.85
		6.5	11	22	44	+2	25	
		10.5	11	21	46	+2	27	
	April	14.5	11	21	00	+2	29	0.76

Astronomical Bulletin. No. 239.

Elements of Comet *b* 1906 (Kopff)—In the Lick Observatory Bulletin No. 97, new elements of this comet are given by Messrs. Crawford and Champreux, depending upon observations at Lick Observatory March 5, 15, and 27.

These give the comet a remarkably large perihelion distance, putting it in the asteroid zone at its nearest approach to the Sun.

ELEMENTS.

T = 1905 Oct. 20.8024 Gr. M. T.
ω = 159° 30′ 06.″1
Ω = 342 09 53.8 } 1906.0
i = 4 12 37.0
q = 3.316454

The position of the comet for April 30 and May 8 will be as follows:

Gr. M. T.		R. A			Decl.			Log Δ	Brightness
		h	m	s	°	′	″		
April	30.5	11	20	11.17	+2	23	07	0.4827	
May	8.5	11	21	11.16	+2	12	30	0.4999	0.58

Secondary Nucleus to Comet *b* 1906 (Kopff's, March 3).—On March 17—the first observation of this comet here—I noticed with the 40-inch telescope a faint star-like condensation close preceding the nucleus. The unusually slow motion of the comet made it uncertain whether the object was a faint star or a secondary nucleus. It was seen again, however, on March 24, at a somewhat greater distance from the nucleus, and was (as before) involved in the tail, and rather difficult to see. By hiding the brighter part of the comet the object appeared as a small star-like nucleus. The following position is referred to the nucleus of the comet:

1906 March 24^d 18^h 40^m Gr. M. T.
Position-angle, 300°.0 (5 obs.) Distance, 4″.68 (4 obs.)

The second nucleus was about 14^m—15^m.

If this object were free from the nebulosity of the main body, it would doubtless appear as a distinct comet— like one of the companions of comet V 1889. It is a similar case to that of SWIFT's comet (*a* 1899), which was observed here and at the Lick Observatory to have a second nucleus or small comet receding from it (see *A. J.* 464).

Looking back over the past 25 years at the various cases of double or multiple comets, it would appear that BIELA's double comet was not such a rare object after all.

The following additional observation of the double head of KOPFF's comet has been made:

1906 March 31^d 13^h 0^m Central Standard Time.
Position-angle 302°.7 Distance 5″.67.

There seems to be a slight change in the angle and distance, but it is quite difficult to measure satisfactorily. The small nucleus is 3 or 4 magnitudes fainter than the principal one.

Astronomical Journal, Supplement to 584-585. E. E. BARNARD.

Ross' Comet *c* 1906.—The following preliminary elements computed by Miss Eleanor A. Lamson, of the U. S. Naval Observatory, were received by telegram March 23. The message came in the new Gerrish code and was transmitted without a single error.

ELEMENTS.

T = 1906 Feb. 2, 147 Gr. M. T.
ω = 278° 43′
Ω = 72 51
i = 81 27
q = 0.743

EPHEMERIS.

Greenwich M. T.	R. A. h m s	Decl. ° ′	Light.
March 25.5	2 27 47	+ 0 26	0.67
29.5	2 38 45	+ 4 11	
April 2.5	2 48 52	+ 7 36	
6.5	2 58 17	+10 42	0.39

The dates of observations employed in the calculation were March 19, 20 and 21.

Elements of Comet *c* 1906.—The following Elements and Ephemeris of Comet *c* 1906 (Ross) have been communicated by Rear-Admiral Asa Walker, U. S. N. Superintendent, Naval Observatory. They were computed by Miss Eleanor A. Lamson from observations made at Glasgow, Mo., on March 19 and at Washington on March 23 and April 2

ELEMENTS.

Time of passing perihelion $= T =$ Feb. 20.93326, 1906 G. M. T.
Longitude of perihelion $= \pi = 348° \ 29' \ 35''.2$
Longitude of node $= \Omega = \ 72° \ 2' \ 28''.1$ } 1906.0
Inclination $= i = \ 83° \ 27' \ 32''.1$
Perihelion distance $= q = 0.722913$
Residuals (O—C): $\cos\beta\Delta\lambda = +4''.8$, $\Delta\beta = +1''.5$.

HELIOCENTRIC COÖRDINATES.

$x = r\,[9.514312] \sin(\ 25° \ 48' \ 58''.7 + v)$
$y = r\,[9.975545] \sin(\ 29 \ \ 2 \ \ 44 \ .8 + v)$
$z = r\,[9.999934] \sin(298 \ \ 42 \ \ 5 \ .1 + v)$

EPHEMERIS.

G. M. T.	R. A. h m s	Dec. ° ′ ″	Light.
1906 Apr. 11.5	3 8 13.0	+14 2 0	0.31
15.5	3 16 21.3	16 31 52	0.27
19.5	3 24 10.1	18 49 33	0.23
23.5	3 31 43.4	20 56 31	0.19
Apr. 27.5	3 39 3.9	22 54 9	0.16
May 1.5	3 46 14.0	24 43 34	0.14
5.5	3 53 15.3	26 25 44	0.12
9.5	4 0 9.5	28 1 37	0.11
May 13.5	4 6 57.7	+29 31 52	0.10

Brightness of March 17 taken as unit.

Astronomical Bulletin, No. 241.
Harvard College Observatory.
April 14, 1906.

Minor Planet 1906 TG.—A letter has been received at this Observatory from Professor Kreutz at Kiel stating that the following circular orbit and ephemeris of Minor Planet 1906 TG, discovered by Professor Max Wolf at Heidelberg, have been computed by Professor A. Berberich, from observations of February 22 and March 5.

CIRCULAR ORBIT.

Epoch 1906 March $5^d.5$ Ber. M. T.
$n = 186° \ 15'.9$
$\Omega = 316° \ \ 1'.2$ } 1906.0
$i = \ 11° \ 43'.2$
$\mu = 312''.32$
$\log a = 0.70360$

EPHEMERIS.

Ber. M. T.		R. A.			Dec.		log Δ
	d	h	m	s	°		
1906 April	6.5	9	6	49	+14	25.1	0.6530
	10.5	9	6	38.	+14	22.6	
	14.5	9	6	40.	+14	19.3	0.6637
	18.5	9	6	55.	+14	15.2	
	22.5	9	7	22.	+14	10.3	0.6748
	26.5	9	8	1.	+14	4.6	
April	30.5	9	8	53.	+13	55.1	0.6859

Magn. 13 — 14.

The correction to the ephemeris according to a Vienna observation of March 23 is + 12ˢ and − 0′.5.

This planet is very interesting on account of its noticeably small mean motion, and, on this account, observations are greatly to be desired.

Note:—The mean distance of Jupiter is 5.203, of this planet, 5.054, so that owing to eccentricity, the planet may at times, be more distant from the Sun than Jupiter.

Astronomical Bulletin No. 240.
Harvard College Observatory,
April 11, 1906.

VARIABLE STARS.

Fifty-Five New Variables. By comparing seven photographs of the region around the star γ Sagittæ, taken in the years 1900-1905, Messrs. M. and G. Wolf of Heidelberg have found fifty-five new variables in this region. All of these stars are faint, none being above the eleventh magnitude at brightest, and so cannot be studied with small telescopes (A. N. 4079). They have been assigned the provisional numbers 117-171.1905.

New Variables 27.1906 Aurigæ and 28.1906 Cassiopeiæ.—These were discovered by Mme. Ceraski on the Moscow photographs and are announced in *A. N.* 4077. Their positions for 1900 are

	R. A.			Decl.	
27.1906 Aurigæ	5ʰ	01ᵐ	20.4ˢ	+30°	16′.4
28.1906 Cassiopeiæ	23	47	05	+58	12

The first, as shown by 15 plates taken in the years 1895-1906 varies between the magnitudes 10 and 12. It is given in the B. D. as of 9.5 magnitude. The period is uncertain but is apparently long.

The second star, from an examination of 24 plates appears to vary between 9.3 and 11.8 magnitude and the period is probably short.

New Variable of the Algol Type 29.1906 Persei.—In *A N* 4078 Mr. J. F. Schroeter, of Christiana, Norway, calls attention to the star B. D. + 41° 854 which has been found by Mr. Sigurd Enebo of Dombaas, Doore, to be a variable of the Algol type. The star is usually of magnitude 9.4 but at intervals of about 13 days or some aliquot part thereof it sinks below the 10th magnitude and becomes invisible in a 7 cm telescope for several hours. Minima occurred on the nights of November 17, and December 26, 1905, and on February 17, 1906.

The position of the star for 1855 is

R. A. = 4ʰ 10ᵐ 11ˢ.8, Decl. = + 41 ° 56′.8

In the Harvard College Observatory Circular 114 Professor Pickering states that Miss E. F. Leland has examined 301 of the Harvard photographs of the region containing this variable and that sufficient data have been obtained to determine not only the period of variation but also the light curve. The period is found to be 13.199 days and the minimum occupies less than one day or about one fifteenth of the entire period. The light curve is symmetrical, the decrease and increase of the light occupying almost the same time. Professor Pickering gives the following elements.

Minimum = J.D. 2410000.08 + 13.199 E.

Enebo's Variable 30.1906.— From an examination of the Harvard photographs it appears that Enebo's Algol variable, + 41° 851 (not 854) will have a minimum on March 29, 1906 at $3^h\ 03^m$ Gr. M. T. Its period is $13^d.199$.

EDWARD C. PICKERING.

Harvard College Observatory, Astronomical Bulletin No. 233.

New Algol-Type Variable 30.1906 Geminorum. In *A. N.* 4079 Messrs. M. and G. Wolf call attention to the star B. D. + 23° 1151, which on forty plates taken in the years 1891-1906 is close to the magnitude 9.0, while on a single plate taken November 3, 1905 it is found to be of 10.0 photographic magnitude. Three plates taken February 20, 1906 show that its light was then varying very rapidly, going down from 9.3 to 10.0 in an interval of 90 minutes. On February 21, it had recovered its usual brightness 9.0. The star was observed visually by Mr. K. Graff of Hamburg on February 23, 25 and 26. On the last two nights the light appeared to be normal, the visual magnitude being 9.6, but on February 23, it rose from 11.0 at $9^h\ 35^m$ to 10.4 at $10^h\ 57^m$ Hamburg mean time. The star is evidently an Algol-type variable, with a period of a little less than three days or some fraction thereof. Its position for 1900 is

R. A. $5^h\ 55^m\ 23^s.60$, Decl. + 23° 08′ 15″.8.

The photographs of this star taken at Heidelberg afford a striking instance of the number of plates which it may be necessary to examine in order to discover the variability of an Algol-type star. The exposure of the plate must be made within an hour or two of the minimum in order to show the variation, and if a long exposure is made the middle of it must coincide very closely with the time of minimum or the normal light of the star during part of the exposure will mask the variation.

The three minima indicated by the photographs and by Mr. Graff's visual observations are satisfied, within the possible errors of observation by a period of 2.94 days. I have been interested to carry this period back to the time of each of the 40 photographs taken when the light appeared to be normal and find that none of them came closer than two hours to the computed time of a minimum. The times of the photographs are given only to the nearest tenth of a day and so are uncertain by a little over an hour.

Date of Photograph		Mag.	Computed Minimum		Epoch
1891 Dec.	19.3	8.9	Dec.	18.10	−1762
	24.5	8.9		23.98	−1760
1892 Dec.	16.4	8.9	Dec.	16.66	−1638
	18.4	9.1			
	19.5	8.9		19.60	−1637
	23.4	8.9		22.54	−1636
	23.5	8.9			
	26.5	8.9		25.48	−1635

1892 Dec.	27.6	8 8	Dec.	28.42	—1634
1893 Mar.	12.4	8.7	Mar.	11.92	—1609
1900 Dec.	20.4	8.9	Dec.	20.96	— 643
	25.4	8.9		26.84	— 641
1903 Dec.	28.6	8.9	Dec.	28.46	— 268
	28.7	8.7			
1904 Jan.	11.3	9.0	Jan.	12.16	— 263
1905 Jan.	1.3	8.8			
	1.3	8.9	Jan.	1.90	— 142
	2.4	8.8			
1905 Jan.	8.3	8.9	Jan.	7.78	— 140
Nov.	3.60	10.0	Nov.	3.66	— 38
	25.4	8.9		24.24	— 31
	25.4	8.9			
	25.5	9.0			
	27.4	8.7		27.18	— 30
	28.4	8 9			
	28.5	8.9			
	28.5	8.7			
	29.5	9.1		30.12	— 29
Dec.	17.4	8.9	Dec.	17.76	— 23
	25.5	8.9			
	26.4	9.1		26.58	— 20
	27.5	8.9			
	27.6	9.1			
	30.4	9.1		29.52	— 19
	30.6	8.9			
	31.5	8.7			
1906 Jan.	1.6	9.0	Jan.	1.46	— 18
	23.3	9.1		22.04	— 11
Feb.	15.3	8.9	Feb.	14.56	— 3
	20.4	9.3			
	20.4	9.5			
	20.5	10.0	Feb.	20.44	— 1
	21.4	9.0			
	Visual Observations.				
	23.37	11.0			
	23.38	11.0	Feb.	23.38	0
	23.42	10.4			
	25.46	9.7			
	25.51	9.5		26.32	1
	28.29	9.6			
	28.39	9.6			
	28.44	9.6		29.26	2

Since the above was given to the printer we have examined a photograph taken at Goodsell Observatory March 1, 1894, 15:33—19:03, Greenwich mean time, which shows the variable to be a little fainter than the 10th magnitude star 20″ following it, so that a minimum must have occurred close to the middle of the exposure of that plate. This requires the period to be 2.9406 days, which period also satisfies the minimum on Nov. 3.60, 1905, within less than an hour.

Future minima may be predicted by the formula

$$\text{Minimum} = \text{J. D. } 2417265.37 + 2^{d}.9406\ E.$$

Minima convenient for observation in America will occur on May 13 at 18^{h}, May 16 at 17^{h}, and May 19 at 15^{h}, Greenwich mean time.

Two New Variables, 31 and 32.1906 (Cephei)—In A. N. 4080 Prof. W. Ceraski announces two new variables discovered by Mme. L. Ceraski on the Moscow photographs. Their positions for 1905 are:

	R. A.			Decl.		
	h	m	s	°	′	″
31.1906	1	08	08.1	+84	36	16.0
32.1906	0	07	45	+73	18.0	

The first is BD. +84°, 19 and it appears to vary between 9.3 and 10.5 magnitude in a period of about a year. The second varies between 10.8 and 13 magnitude in a period of about 282 days.

Approximate Magnitudes of Variable Stars on April 1, 1906.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn
X Androm.	0	10.8	+46	27	13.5*d*	V Monoc.	6	17.7	− 2	9	10.5*d*
T "		17.2	+26	26	12.5	R "		33.7	+ 8	49	11.7
T Cassiop.		17.2	+55	14	8.8 *i*	S Lyncis		35.9	+58	0	11.0*d*
R Androm.		18.8	+38	1	8.2 *i*	X Gemin.		40.7	+30	23	11.8 *i*
Y Cephei		31.3	+79	48	11	W Monoc.		47.5	− 7	2	11.5*d*
U Cassiop.		40.8	+47	43	13.0*d*	Y "		51.3	+11	22	14.3
V Androm.		44.6	+35	6	11.0*d*	X "		52.4	− 8	56	7.3
RR "		45.9	+35	50	13	R Lyncis		53.0	+55	28	11.8*d*
W Cassiop.		49.0	+58	1	12	RS Gemin.		55.2	+30	40	10.3 *i*
U Androm.	1	9.8	+40	11	14.5	R "	7	1.3	+22	52	12 2
S Cassiop		12.3	+72	5	14.0 *i*	V Can. Min.		1.5	+ 9	1	15
RU Androm		32.5	+38	10	14	R " "		3.0	+10	11	8.5 *i*
Y "		33.7	+38	50	9.5*d*	RR Monoc.		12.4	+ 1	17	14
X Cassiop.		49.8	+58	46	13.0*d*	V Gemin.		17.6	+13	7	14.3*d*
U Persei		52.9	+54	20	9.1 *i*	S Can. Min.		27.3	+ 8	32	10.8*d*
R Arietis	2	10.4	+24	35	13 *d*	Z Puppis		28.3	−20	27	13 *d*
W Androm.		11.2	+43	50	12.3 *i*	T Can. Min.		28.4	+11	58	9.4*d*
Z Cephei		13.0	+81	13	10.3 *i*	U " "		35.9	+ 8	37	10.2*d*
S Persei		15.7	+58	8	8.7	S Gemin.		37.0	+23	40	13.3*d*
RR Cephei		29.4	+80	42	12 *i*	T "		43.3	+23	59	9.9 *i*
R Triang.		31.0	+33	50	9.2*d*	U "		49.2	+22	16	14.2
T Arietis		42.8	+17	6	8.7 *i*	U Puppis		56.1	−12	34	9.2 *i*
W Persei		43.2	+56	34	10.4	R Cancri	8	11.0	+12	2	11.3*d*
U Arietis	3	5.4	+14	25	10.0*d*	V "		16.0	+17	36	10.7 *i*
Y Persei		20.9	+43	50	9.7*d*	RT Hydrae		24.7	− 5	59	8.3 *i*
R "		23.7	+35	20	12.2*d*	U Cancri		30.0	+19	14	13.7
Nova Per. No. 2		24.4	+43	34	13.0*d*	X Urs. Maj.		33.9	+50	29	8.9
T Tauri	4	16.2	+19	18	11	S Hydrae		48.4	+ 3	27	9.0*d*
W "		22.2	+15	49	11.7*d*	T "		50.8	− 8	46	10.7 *i*
R "		22.8	+ 9	56	13.5*d*	T Cancri		51.0	+20	14	8.0
S "		23.7	+ 9	44	10.4*d*	S Pyxidis	9	0.7	−24	41	13
T Camelop.		30.4	+65	57	8.4*d*	W Cancri		4.0	+25	39	14 *d*
X "		32.6	+74	56	11.8*d*	X Hydrae		30.7	−14	15	7.5 *i*
V Tauri		46.2	+17	22	9.0 *i*	Y Draconis		31.1	+78	18	13
R Orionis		53.6	+ 7	59	12 *d*	R Leo. Min.		39.6	+34	58	10.6*d*
R Leporis		55.0	−14	57	9 *i*	RR Hydrae		40.4	−23	34	11.7*d*
T "	5	0.6	−22	2	11.0	R Leonis		42.2	+11	54	4.9 *i*
V Orionis		0.8	+ 3	58	10.0 *i*	Y Hydrae		46.4	−22	33	7
R Aurigae		9.2	+53	28	9.2 *i*	V Leonis		54.5	+21	44	10.7*d*
W "		20.1	+36	49	<14.5	R Urs. Maj.	10	37.6	+69	18	8.3*d*
S "		20.5	+34	4	11.0	V Hydrae		46.8	−20	43	8.5 *i*
S Orionis		24.1	− 4	46	11.0 *i*	W Leonis		48.4	+14	15	9.3 *i*
S Camelop.		30.2	+68	45	10.5*d*	S "	11	5.7	+ 6	0	<12
T Orionis		30.9	− 5	32	10.5	R Comae		59.1	+19	20	14.0
RR Tauri		33.3	+26	19	<11.2	RX Virginis		59.6	− 5	13	8.2
U Aurigae		35.6	+31	59	11.0 *i*	RW "	12	2.1	− 6	12	7.3
Z Tauri		46.7	+15	46	14	T "		9.5	− 5	29	12.2*d*
RU "		47.3	+15	42	10.5 *i*	R Corvi		14.4	−18	42	13.0*d*
V Camelop.		49.4	+74	30	8.8 *i*	T Can. Ven.		25.2	+32	3	8.7 *i*
U Orionis		49.9	+20	10	9.1 *i*	Y Virginis		28.7	− 3	52	13.3*d*
Z Aurigae		53.7	+53	18	10.8	T Urs. Maj.		31.8	+16	2	13.3
X "	6	4.4	+50	14	10.5*d*	R Virginis		33.4	+ 7	32	10.7
V "		16.5	+47	45	9.5 *i*	RS Urs Maj.		34.4	+59	3	12.8*d*

Approximate Magnitudes of Variable Stars on April 1, 1906.—
(Continued.)

Name.	h	R. A. 1900. m	Decl 1900. ° ′	Magn.
S Urs. Maj.	12	39.6	+61 38	8.0 *i*
RU Virginis		42.2	+ 4 42	8.0
U "		46.0	+ 6 6	9.6*d*
RT "		57.6	+ 5 43	8.5
RV "	13	2.7	−12 38	14
V "		22.6	− 2 39	10.5*d*
R Hydrae		24.2	−22 46	6.5 *i*
S Virginis		27.8	− 6 41	10.5*d*
T Urs. Min.		32.6	+73 57	9.0 *i*
R Can. Ven.		44.6	+40 2	7.2
Z Bootis	14	1.7	+13 58	10.3*d*
S "		19.5	+54 16	9.6*d*
RS Virginis		22.3	+ 5 8	<12
R Camelop.		25.1	+84 17	11.2*d*
V Bootis		25.7	+39 18	11.0*d*
R "		32.8	+27 10	8.7*d*
V Librae		34.8	−17 4	10.7*d*
U Bootis		49.7	+18 6	11.0 *i*
RT Librae	15	0.8	−18 21	10.5 *i*
T "		5.0	−19 38	12.0 *i*
Y "		6.4	− 5 38	9.0
S "		15.6	−20 2	12.0*d*
S Coronae		17.3	+31 44	7.4 *i*
RS Librae		18.5	−22 33	8.3
X "		30.4	−20 50	12
S Urs. Min.		33.4	+78 38	11.5
Z Librae		40.7	−20 49	12
R Coronae		44.4	+28 28	6.0
— "		45.3	+37 49	8.5
V "		46.0	+39 52	8.5 *i*
Z Scorpii	16	0.1	−21 28	10.5 *i*
RR Herc.		1.5	+50 46	9.0
R "		1.7	+18 38	<12
U Serpentis		2.5	+10 12	10 *i*
RU Herc.		6.0	+25 20	10.0*d*
R Scorpii		11.7	−22 42	<12
S "		11.7	−22 39	11.2
W Coronae		11.8	+38 3	10.1*d*
W Ophiuchi		16.0	− 7 28	11
V "		21.2	−12 12	9
U Herc.		21.4	+19 7	10.2 *i*
T Ophiuchi		28.0	−15 55	9
SS Herculis		28.0	+ 7 3	10.5
S Ophiuchi		28.5	−16 57	11.0*d*
W Herculis		31.7	+37 2	10.8 *i*
R Draconis		32.4	+66 58	7.3 *i*
S Herculis		47.4	+15 7	8.5
R Ophiuchi	17	2.0	−15 58	12.0 *i*
Z "		14.5	+ 1 37	11.5
RS Herculis	17	17.5	+23 1	8.5
RS Ophiuchi		44.8	− 6 40	10.5
RT "		51.7	+11 10	12.0
RY Herculis		55.4	+19 29	8.5
W Draconis	18	5.4	+65 56	9.5*d*
T Herc.ulis		5.3	+31 0	9.2*d*
W Lyrae		11.5	+36 38	11.0*d*
T Serpentis		23 9	+ 6 14	11.8
X Ophiuchi		33.6	+ 8 44	7.8
RY Lyrae				11
R Aquillae	19	1.6	+ 8 5	6.5 *i*
V Lyrae		5.2	+29 30	12 *d*
RU "		9.1	+41 8	12
RS "		9.3	+33 15	11.0 *i*
TZ Cygni		13.4	+50 0	11.5
T Sagittae		17.2	+17 28	9.5
R Cygni		34.1	+49 58	7.5
RV Aquilae		35.9	+ 9 42	11.5*d*
RT Cygni		40.8	+48 32	11.5
TU "		43.3	+48 49	<12
X Aquilae		46.5	+ 4 12	12 *d*
X Cygni		46.7	+32 40	7.5*d*
Z "		58.6	+49 46	13
S "	20	3.4	+57 42	<12
RU Aquilae		8.0	+12 42	<12
RS Cygni		9.8	+38 28	7.6*d*
R Delphini		10.1	+ 8 47	9.7*d*
U Cygni		16.5	+47 35	10.3*d*
RW "		25.2	+39 39	9.0
Z Delphini		28.1	+17 6	10.5
S "		38.5	+16 44	10.5
T "		40.7	+16 2	<12.2
V "		43.2	+18 58	<12
RZ Cygni		48.5	+46 59	11 *i*
X Delphini		50.3	+17 16	12 *d*
R Vulpeculae		59.9	+23 26	9.0*d*
X Cephei	21	3.6	+82 40	13.5
T "		8.2	+68 5	6.7
S "		36.5	+78 10	11.2 *i*
SS Cygni		38.8	+43 8	10.0*d*
S Lacertae	22	24.6	+39 48	13
R "		38.8	+41 51	10 *d*
V Cassiop.	23	7.4	+59 8	12.5
W Pegasi		14.8	+25 24	10 d
Z Cassiop.		39.7	+56 2	14.5*d*
RR "		50.6	+53 10	13 *d*
R "		53.3	+50 50	12.8
Y "		58.2	+55 7	12.0*d*

The letter *i* denotes that the light is increasing, the letter *d* that the light is decreasing, the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled by Mr. Leon Campbell of the the Harvard College Observatory, from observations made at the Vassar College, Eadie, Whiteside and Harvard Observatories.

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours.]

U Cephei.

	d	h
June	1	6
	3	18
	6	6
	8	18
	11	5
	13	17
	16	5
	18	17
	21	5
	23	17
	26	4
	28	16

Z Persei

	d	h
June	1	19
	4	20
	7	21
	10	23
	14	0
	17	1
	20	3
	23	4
	26	6
	29	7

Algol.

	d	h
June	2	2
	4	23
	7	20
	10	17
	13	13
	16	10
	19	7
	22	4
	25	1
	27	21
	30	18

RT Persei

	d	h
June	1	1
	1	21
	2	17
	3	14
	4	10
	5	7
	6	3
	7	0
	7	20
	8	16
	9	13
	10	9
	11	5
	12	2
	12	22
	13	18
	14	15
	15	11
	16	8
	17	4

RT Persei

	d	h
June	18	0
	18	21
	19	17
	20	14
	21	10
	26	6
	23	3
	23	23
	24	19
	25	16
	26	12
	27	9
	28	5
	29	1
	29	22
	30	18

S Cancri.

	d	h
June	9	0
	18	12
	28	0

S Antliæ

Period $7^h\ 46^m.8$

	d	h
June	1	16
	2	15
	3	15
	4	14
	5	13
	6	13
	7	12
	8	11
	9	11
	10	10
	11	9
	12	9
	13	8
	14	7
	15	7
	16	6
	17	5
	18	5
	19	4
	20	4
	21	3
	22	2
	23	1
	24	1
	25	0
	25	23
	26	23
	27	22
	28	21
	29	21
	30	20

S Velorum.

	d	h
June	2	22
	8	20
	14	19

S. Velorum.

	d	h
June	20	17
	26	16

W Urs. Maj.

Period 4^h

June 1-30 16^h

RR Velorum

	d	h
June	1	15
	3	11
	5	8
	7	4
	9	1
	10	22
	12	19
	14	15
	16	12
	18	7
	20	4
	22	0
	23	21
	25	17
	27	14
	29	10

Z Draconis.

	d	h
June	1	19
	3	4
	4	12
	5	21
	7	6
	8	14
	9	23
	11	7
	12	16
	14	0
	15	9
	16	18
	18	2
	19	11
	20	19
	22	4
	23	13
	24	21
	26	6
	27	14
	28	23
	30	7

δ Libræ

	d	h
June	2	11
	4	19
	7	3
	9	11
	11	18
	14	2
	16	10
	18	18
	21	2
	23	10
	25	18

δ Libræ

	d	h
June	28	1
	30	9

U Coronæ

	d	h
June	3	22
	7	8
	10	19
	14	6
	17	17
	21	4
	24	15
	28	2

R Aræ

	d	h
June	3	5
	8	15
	13	1
	17	11
	21	21
	26	8
	30	18

U Ophiuchi.

	d	h
June	1	8
	2	4
	3	0
	3	20
	4	17
	5	13
	6	9
	7	5
	8	1
	8	21
	9	17
	10	13
	11	10
	12	6
	13	2
	13	22
	14	18
	15	14
	16	10
	17	7
	18	3
	18	23
	19	19
	20	15
	21	11
	22	7
	23	3
	24	0
	24	20
	25	16
	26	12
	27	8
	28	4
	29	0
	29	20
	30	17

Z Herculis.

	d	h
June	2	11
	4	14
	6	11
	8	14
	10	11
	12	14
	14	11
	16	14
	18	11
	20	14
	22	11
	24	13
	26	10
	28	13
	30	10

RS Sagittarii.

	d	h
June	1	21
	4	7
	6	17
	9	3
	11	13
	13	23
	16	9
	18	19
	21	5
	23	15
	26	1
	28	11
	30	21

V Serpentis.

	d	h
June	3	12
	6	23
	10	10
	13	21
	17	7
	20	18
	24	5
	27	6

RX Herculis.

	d	h
June	1	8
	2	6
	3	3
	4	0
	4	22
	5	19
	6	16
	7	14
	8	11
	9	8
	10	6
	11	3
	12	0
	12	21
	13	19
	14	16
	15	14
	16	11

Minima of Variable Stars of the Algol Type.—Continued.

RX Herculis.

	d	h
June	17	8
	18	6
	19	3
	20	0
	20	22
	21	19
	22	16
	23	14
	24	11
	25	8
	26	6
	27	3
	28	0
	28	22
	29	19
	30	16

RR Draconis.

June	1	14
	4	10
	7	6
	10	2
	12	22
	15	18
	18	14
	21	10
	24	6
	27	2
	29	22

RV Lyræ

	d	h
June	2	1
	5	16
	9	6
	12	21
	16	11
	20	1
	23	16
	27	6
	30	20

U Sagittæ

June	1	17
	5	2
	8	11
	11	20
	15	5
	18	15
	22	0
	25	9
	28	18

SY Cygni.

June	3	13
	9	13
	15	13
	21	13
	27	13

WW Cygni.

June	4	5

WW Cygni.

	d	h
June	7	13
	10	21
	14	4
	17	12
	20	20
	24	3
	27	11
	30	18

SW Cygni

June	4	4
	8	18
	13	8
	17	21
	22	11
	27	1

VW Cygni.

June	6	23
	15	9
	23	20

UW Cygni

June	2	6
	5	17
	9	4
	12	16
	19	13
	22	23

UW Cygni

	d	h
June	26	10
	29	21

W Delphini

June	4	6
	9	2
	13	21
	18	16
	23	12
	28	7

Y Cygni

June	1	18
	3	5
	4	18
	6	5
	7	18
	9	5
	10	18
	12	5
	13	18
	15	5
	16	18
	18	5
	19	18
	21	5
	22	18
	24	5
	25	17

Y Cygni

	d	h
June	27	5
	28	17
	30	4

VV Cygni

June	1	15
	3	3
	4	14
	6	1
	7	13
	9	0
	10	12
	11	23
	13	11
	14	22
	16	10
	17	21
	19	9
	20	20
	22	7
	23	19
	25	6
	26	18
	28	5
	29	17

UZ Cygni

June	9	12
July	10	19

Variable Stars of Short Period not of the Algol Type.

The times of maxima only are given; the times of minima may be obtained by subtracting the interval printed in parentheses under the name of the star.

Y Aurigæ

	d	h
	(−0	18)
June	2	22
	6	19
	10	16
	14	12
	18	9
	22	6
	26	2
	29	23

W Geminorum

	(− 2	16)
June	7	15
	15	9
	23	3
	30	21

ξ Geminorum

	(− 5	0)
June	10	14
	20	17
	30	21

V Carinæ

	d	h
	(− 2	4)
June	1	9
	8	2
	14	18
	21	11
	28	4

T Velorum

	(− 1	9)
June	3	14
	8	5
	12	20
	17	12
	22	3
	26	19

W Carinæ

	(− 1	0)
June	1	11
	5	19
	10	4
	14	13
	18	22
	23	7

W Carinæ

	d	h
June	27	16

S Muscæ

	(− 3	11)
June	4	4
	13	20
	23	12

T Crucis

	(− 2	1)
June	2	9
	9	3
	15	21
	22	14
	29	8

R Crucis

	(− 1	9)
June	1	4
	6	23
	12	19
	18	15
	24	11
	30	7

S Crucis

	d	h
	(− 1	12)
June	5	4
	9	21
	14	13
	19	6
	23	22
	28	15

W Virginis

	(− 8	4)
June	9	10
	26	17

V Centauri

	(− 1	12)
June	3	23
	9	10
	14	22
	20	10
	25	22

R Triang. Austr.

	(− 1	10)
June	1	19
	5	4

R Triang. Austr.

	d	h
	(− 1	10)
June	8	14
	11	23
	15	8
	18	18
	22	3
	25	12
	28	22

S Triang. Austr.

	(− 6	0)
June	7	7
	13	14
	19	22
	26	6

S Normæ

	(− 4	9)
June	8	1
	17	19
	27	13

R V Scorpii

	(−1	10)
June	4	1

Variable Stars of Short Period not of the Algol Type.—Continued.

R V Scorpii

	d	h
June	10	3
	16	4
	22	6
	28	7

X Sagittarii

	d	h
	(−2	21)
June	6	21
	13	21
	20	21
	27	22

Y Ophiuchi

	d	h
	(−6	5)
June	12	11
	29	24

W Sagittarii

	d	h
	(−3	0)
June	8	8
	16	22
	23	12

Y Sagittarii

	d	h
	(−2	2)
June	6	18
	12	13
	18	7
	24	2
	29	20

U Sagittarii

	d	h
	(−3	0)
June	1	6
	8	0
	14	18
	21	12
	28	5

β Lyræ

	d	h
	(−3	7)
	(−3	2)
June	1	16
	7	22
	14	15
	20	21
	27	13

κ Pavonis

	d	h
	(−4	9)
June	4	0
	13	2
	22	4

U Aquilæ

	d	h
	(−2	5)
June	7	18
	14	19
	21	19
	28	20

U Vulpeculae

	d	h
	(−2	3)
June	6	9
	14	8

U Vulpeculae

	d	h
June	22	8
	30	7

SU Cygni

	d	h
	(−1	8)
June	2	2
	5	22
	9	18
	13	15
	17	11
	21	7
	25	4
	29	0

η Aquilae

	d	h
	(−2	9)
June	5	16
	12	20
	20	0
	27	4

S Sagittae

	d	h
	(−3	10)
June	4	15
	13	0
	21	9
	29	19

X Cygni

	d	h
	(−6	19)
June	5	18
	22	3

T Vulpeculae

	d	h
	(−1	10)
June	1	5
	5	16
	10	2
	14	13
	18	23
	23	10
	27	20

WZ Cygni
Minimum
Period 14^h

	d	h
June	1	6
	2	10
	3	14
	4	18
	5	22
	7	2
	8	6
	9	10
	10	14
	11	18
	12	22
	14	2
	15	6
	16	11
	17	15
	18	19
	19	23

WZ Cygni
Minimum
Period 14^h

	d	h
June	21	3
	22	7
	23	11
	24	15
	25	19
	26	23
	28	3
	29	7
	30	11

TX Cygni

	d	h
	(−5	3)
June	4	22
	19	15

VY Cygni

	d	h
	(−2	2)
June	6	17
	14	14
	22	10
	30	7

δ Cephei

	d	h
	(−1	9)
June	1	1
	6	10
	11	19
	17	3
	22	12
	27	21

GENERAL NOTES.

Photographing the Flocculi of the Sun. Some very interesting results have been secured at the Solar Observatory on Mount Wilson in photographing the flocculi of the Sun by the aid of the new spectroheliograph which has been in use there since last October. This new instrument has high dispersion prisms and considerable focal length of the collimator and of the camera objectives, on this account the $H\delta$ line and the λ 4045 line have been successfully used with two prisms in photographing the iron and the hydrogen flocculi.

In the work of last November photographs in the lines just named were secured and also one of the Calcium flocculi at low level when the slit was set on H_1. These photographs show abundance of these various flocculi far inward on the solar disc so conspicuously that it is a surprise and a pleasure to study them visually. The fact that the spectroscopist can now study these cloud-like forms of metallic vapor of iron. calcium and other substances upon and high above the photosphere of the Sun is indeed a grand achievement for the modern spectroscopist.

Professor Keeler's Remains to be moved to Allegheny Observatory. Arrangements have been made by the Trustees of Allegheny Observatory to place the cremated remains of Professor James E. Keeler in the vault under the mounting of the 30-inch reflecting telescope erected to his memory.

Mrs. Keeler and her two children and also David T. Day will accompany the remains from San Francisco to Allegheny about the first of May. There will be

no ostentatious ceremony, but a simple service will be held in the beautiful lecture room of the New Observatory to which the personal friends of Professor Keeler will be invited.

Professor Keeler was the director of Allegheny Observatory for seven years prior to accepting the directorship of the Lick Observatory. There he made some of his greatest discoveries—among them the meteoric constitution of the rings of Saturn. Professor Keeler had a great affection for the Allegheny Observatory having assisted Professor Langley in his spectrobolometric researches before he went to California. It is through the wishes of Mrs. Keeler and other members of the family that the remains of Professor Keeler shall rest under the telescope erected to his memory.

The Solar Observatory of Mt. Wilson. We have received the report of the Director of the Solar Observatory of Mt. Wilson, Professor George E. Hale, for the year 1905. This report is an extract from the fourth year book of the Carnegie Institution of Washington, D. C. It will be remembered that the first or preliminary report, which will be found in year book No. 3. gave account of the grant of $150,000 for the building of the Solar Observatory on Mount Wilson in California and for the maintenance of it for the year 1905.

Previous to the beginning of the year 1905, tests were made of the quality of the site for observing purposes. A small telescope was first used, then a large one of long focal length to get knowledge of the atmospheric conditions prevailing on the mountain day and night for critical visual work. Tests were also made of solar radiation by means of the pyrheliometer and the spectrobolometer, by the aid of an expert from the solar observatory at Washington, and finally Professor E. E. Barnard from Yerkes Observatory with his large photographic camera was employed to test the site for photographic work. The results of these apparently careful and severe tests are favorable in a high degree. They seem to show a transparent atmosphere partly due probably to elevation, low wind velocity, unusual purity of the mountain air, and possibly to wave conditions in the atmosphere. Upon this point particularly we do not notice any testimony. The value of this feature of an observing station for critical work under high power is so great that we presume it has not been overlooked in the tests at this station. It has been so large a factor in the best sites for astronomical work at other places that working astronomers can but think about it. The plan of research at the Solar Observatory is as follows.

(1) The investigation of the Sun (*a*) as a typical star, in connection with the study of stellar evolution; (*b*) as the central body of the solar system, with special reference to possible changes in the intensity of its heat radiation, such as might influence the conditions of life upon the Earth.

(2) The choice of an effective mode of attack, involving (*a*) the application of new methods in solar research; (*b*) the investigation of stellar and nebular phenomena, especially such as are not within the reach of existing instruments; and (c) the interpretation of these celestial phenomena by means of laboratory experiments.

(3) The design and construction of a large reflecting telescope and of new types of instruments peculiarly adapted for the purposes in view, with special reference to the possibilities of research through the study of celestial objects under laboratory conditions.*

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* See the development of a New Observatory, Publications of the Astronomical Society of the Pacific, Vol. XVII, p. 41. 1905.

(4) The accomplishment of the foregoing purposes at a site where the atmospheric conditions have been shown to be exceptionally favorable: Mount Wilson (5,886 feet), in southern California (lat. + 34° 13′ 26″, long. W. 118° 3′ 40″).

(5) The furtherance of international coöperation in astrophysical research through the invitation to Mount Wilson, from time to time, of investigators specially qualified to take advantage of the opportunities afforded by the Solar Observatory.

The staff at the Observatory are Ferdinand Ellerman and Walter S. Adams, assistant astronomers. Mr. Charles S. Backus is a general assistant. At the Pasadena office and instrument shop the work of construction is carried on under the supervision of Professor G. W. Ritchey, astronomer and superintendent of instrument construction.

Professor Winslow Upton, Director of the Ladd Observatory of Brown University, and Professor L. H. Gilmore, of Throop Polytechnic Institute, were engaged in special work at the Solar Observatory during the summer of 1905.

During 1905 the following expeditions have conducted observations on Mount Wilson in coöperation with the Solar Observatory.

Hooker Expedition: Edward E. Barnard, astronomer of the Yerkes Observatory, in charge.

Smithsonian Expedition: Charles G. Abbot, aid acting in charge of the Smithsonian Astrophysical Observatory, in charge; Leonard R. Ingersoll, University of Wisconsin, assistant.

Miss Clerke's Modern Cosmogonies.* The appearance of this timely volume by the well known authoress of the "History of Astronomy during the 19th Century", "The System of the Stars", and "Problems in Astrophysics" is sure to meet a hearty welcome from all non-technical readers; and even the professional astronomer will find it a convenient source of systematized information, which will prove well nigh indispensable. So far as we are aware this is the only recent popular treatise on the theories of Cosmogony; and of course there exists no scientific treatise on the subject. Faye's analogous work entitled "L' origin du Monde" appeared about a quarter of a century ago, and therefore is largely antiquated, and besides in a foreign language.

In addition to its modern quality, Miss Clerke's work is historically very comprehensive, tracing the development of our theories of Cosmogony from their earliest germs, and with the characteristic fairness which is so marked in her History of Astronomy, and has rendered that work a standard source of reference for all readers, whether lay or scientific. It is only by reading such a work that one can form an estimate of the comparative merits of the different theories and the transformations they have undergone. One sees in that way also the relations between the different theories, their defects, and possible future improvements. The suggestions thus thrown out often bear fruit in exact researches which extend the domain of science itself. The writer of this review has no hesitation in recording his own deep obligation to the works of Miss Clerke, for suggesting several investigations which otherwise might not have been undertaken. So it is with students and scientific workers generally: suggestion is the origin of scientific research. It has been my observation that the most important investigations are seldom undertaken except by those who read gen-

* Modern Cosmogonies, by Agnes M. Clerke, London, Adam Charles Black, 1905.

eral works, and therefore appreciate to the full the defects in our knowledge at a given epoch. In this way the importance of general works is much greater than some investigators are inclined to admit. Few who read only special papers ever obtain a sufficiently general view of a subject to furnish the basis for important extensions likely to round it out when viewed in its entirety.

The present work is divided into sixteen chapters as follows:

CONTENTS.

Chapter

I. From Thales to Kant.
II. The Nebular Hypothesis.
III. Criticisms of the Nebular Hypothesis.
IV. The Nebular Hypothesis Varied and Improved.
V. Tidal Friction as an Agent in Cosmogony.
VI. The Fission of Rotating Globes.
VII. World-Building out of Meteorites.
VIII. Cosmogony in the Twentieth Century.
IX. Protyle: What is it?
X. Universal Forces.
XI. The Inevitable Ether.
XII. The Forms of Nebulæ.
XIII. The Procession of Suns.
XIV. Our own System.
XV. Remnants and Survivals.
XVI. Life as the Outcome.

The work is 12mo, 287 pages, with good index, and the contents of the work is sufficiently indicated by these titles of the chapters. It is well written throughout, in a clear simple style, and the historical details are cited from the best authorities. The references are both abundant, and accurate; so that the work seems indispensable alike to the busy scientific investigator and the general reader and student. It embodies a digest of the latest investigations of Darwin, Jeans, Roberts, and others; and treats of the recent researches by Thomson, Larmor, and others on the ether and radium, in their bearings on Cosmical physics.

If one is inclined to consider Cosmogony as the most difficult and least developed of the Sciences, he may yet remember that year by year it presses more and more urgently for systematic attention. Already some very important advances have been made, and upon this basis the future structure of the science must be erected. As the motions of the heavenly bodies have been fully treated by mathematicians during the past two centuries, it seems certain that in the future Cosmogony will absorb more and more of the world's stock of genius. How the planets attained their present conditions, and what are the processes involved in the production of worlds, stars, and systems, must ever be a subject of supreme interest to the human mind; and no one can afford to be in the dark regarding the advances of Modern Cosmogony which Miss Clerke has sketched with her characteristic penetration. This work well deserves a place in the Library of every student and thinker, and we predict that it will become one of the classics of our popular scientific literature.

U. S. Naval Observatory,
Mare Island, California. April 10, 1905. T. J. J. See.

Star-Streaming.—Ever since the measures of the proper motions of stars have become fairly numerous, the study of the general arrangement of these motions has been a fascinating one, in that one might hope to gain from it some clue to systematic structure of the sidereal universe. The first point sought for, and apparently found, has been the direction of the movement of the solar system through space,—this being shown by a general tendency of the average motion of stars in all parts of the heavens away from the point on the celestial sphere toward which the Sun is moving, and toward the opposite point. Years ago Mr. Richard A. Proctor called attention to the fact that aside from this general tendency of motions away from the Apex of the Sun's Path, the proper motions of stars are not in all directions at random, but that large groups of stars here and there have common directions of movement, and the different groups move in different directions. Now comes the announcement of a remarkable discovery by Professor Kapteyn, from a study of his enormous number of photographic measures of proper motion, that there are two great star streams moving past one another along a diameter of the Milky Way. The following extract from a report of the British Association in South Africa, by Mr. A. R. Hinks published in the March *Observatory* contains much of exceedingly great interest on this subject:

"Most astronomers have heard somewhat vague reports of a great address delivered by Professor Kapteyn at the St. Louis Exposition Congress in 1904, which has not yet been published. One or two have had the privilege of reading the manuscript; but it is curious—and perhaps a warning to others—that to announce a great discovery to a scientific congress may render it inaccessible for a long time afterwards. Even to repeat the substance of it twelve months later, as Professor Kapteyn did at Cape Town, does not bring it very much nearer publication; for although the Sectional Committee resolved to ask the Council to print the address in full in the Association Report, and the Council agreed, that Report will probably not appear for some months. The consequence of this delay is that, eighteen months after it was first announced, comparatively few people know what "star-streaming" means. The members of Section A at Cape Town are a happy minority, and the writer will be so bold as to set down his recollections of an intensely interesting but rather complicated subject.

If the Sun were at rest in space, and the real motions of the stars were distributed at random, the proper motions of the stars in a small region of the sky might be represented by lines radiating from a point, and the mean length of the lines in any sector would be independent of the position-angle of the sector. Substitute a mean radius for the bundle of radii in each sector, and the extremities of these radii lie on a circle. Now introduce the effect of a solar motion. Each radius is bent back more or less away from the apex and its length is altered; those in front are shortened, those behind lengthened, and the envelope of the mean radii becomes a kind of oval, whose axis of symmetry is directed to the apex. In part 5 of the publications of the Astronomical Laboratory of Groningen, Professor Kapteyn has shown how from the shape of this oval it is possible to deduce "the distribution of cosmical velocities," always supposing that their directions are actually distributed at random, and as the result of many pages of disagreeable-looking integration he produced a set of tables all ready to interpret the meaning of the shapes that the ovals would be found to assume when the observed proper motions of the stars were tabulated and the figures constructed. But a great surprise was in store for him when he proceeded to

construct the ovals. They did not come out ovals at all, but curious kite-shaped figures, whose principal characteristic was an absurd absence of symmetry about that axis with respect to which they should have been symmetrical. No possible change in the adopted apex of the solar motion gets rid of this dissymmetry, which is most marked about the poles of the Milky Way.

And now for the interpretation. Practically the whole of the stars, according to Professor Kapteyn, belong to one or other of two great streams, and the *apparent* vertices of their motions lie 140° apart, at points about 7° south of α Orionis and 2° south of η Sagittarii. The true vertices of their motion are at ξ Orionis and the point diametrically opposite it—that is to say, the streams are moving past one another along a diameter of the Milky Way.

In the course of the discussion which followed, Professor Darwin expressed his admiration of the development which the science of stellar statistics has received at the hands of Professor Kapteyn, but admitted a grudge against these results, which furnish no confirmation of the theory put forward in his address! Sir David Gill expressed the amazement of the practical astronomer that the systematic character of proper motions should have escaped notice for so long, and was sure that the steps which Professor Kapteyn advised for the elucidation of this matter would command the best efforts of the best observatories of the world.

There can be no question of the revolutionary character of this discovery, and it will take some reflection to make sure of what is left of the supposed established facts of stellar astronomy. What will happen to the precision constant may easily be guessed. An apex of the Sun's way becomes indefinable when two systems are involved. But perhaps the most interesting point is this: What relation do the stars which have up to the present shown sensible proper motion bear to the stars in general and to the star-clouds of the Milky Way? Kapteyn says that the brighter Bradley stars with proper motion are nearly equally distributed, but that the fainter are condensed on the plane of the Milky Way. Newcomb considers the latter part of this result unreliable, and prefers to say that the distribution of stars whose proper motion is certainly determined bears no relation to the plane. The difference is clearly of extreme importance—just the difference between having found out something of the structure of the whole visible universe and having analyzed into two separate parts the particular star-cloud in which our Sun is involved. For the solution of this and many other points in the theory of star-streaming which are at present obscure, we await with lively impatience the appearance of Professor Kapteyn's detailed discussion."

Motion of Stars in the Line of Sight. A worthy correspondent asks how the motions of the stars in line of sight are measured. This motion of stars is now more commonly called radial motion to distinguish it from proper motion which is always at right angles to the motion in line of sight.

The radial motion of a star is measured by the Doppler-Fizeau principle, which is usually stated as follows:—When the distance between the observer and a body emitting uniform vibrations is *increasing* the number of vibrations received in a second is *decreased*, and their wave-lengths, real or apparent, are correspondingly *increased*; but if the distance is *decreasing* exactly the opposite is true.

These interesting facts in regard to the motion and behavior of light vibrations is well illustrated by sound waves from the whistle of an engine of one of two fast railway trains moving in opposite directions. Any one can notice the

change of pitch of the tone of the whistle from the higher to the lower key as they approach and recede. The explanation is easy from the foregoing principle.

But the main point in our querist's mind is probably not yet answered. He wants to know how the astronomer can measure the motion of a star which is moving towards him or away from him and determine its velocity in miles by noticing that the lines in the spectrum of its light are shifted from their normal places either towards its red, or its violet end as the motion of the light source is from or towards the observer.

The unit of measure in spectroscopy is one ten-millionth of a millimeter. The velocity of light is 186,330 miles per second. The wave-lengths of many of the lines in the spectrum are known. The shift of the known lines can be measured in units of their wave-lengths. Then, knowing that the shift of a line in the spectrum is to its normal wave-length as the velocity of a star in line of sight is to the velocity of light, the velocity of the star is easily found.

Our querist will find full explanation of this in Young's Manual of Astronomy and in Scheiner's Spectroscopy, as translated by Professor Frost of Yerkes Observatory.

It is a noteworthy fact that the modern spectroscopist can now detect celestial motions of the bright heavenly bodies which are less than one-half mile per second.

Laboratory Astronomy. A new book has been issued from the press of Ginn and Company, entitled Laboratory Astronomy. It is the usual 8vo., in size, containing 189 pages. Its author is Robert Wheeler Wilson, Professor of Astronomy in Harvard University. The book is the result of the author's experience in teaching an outline course in Astronomy in which the fundamental principles are developed by laboratory methods. Simple observations are arranged in logical order and carried far enough to explain a few of the important celestial motions. By this means a foundation is laid in the mind of the student for a better comprehension and a fuller grasp of some of the leading facts of Astronomy than can be attained possibly in another way so quickly and so well. The laboratory method is the true way to teach elementary astronomy.

In this new book the author begins with a study of the diurnal motion of the Sun; he soon finds that its path on the hemisphere is sometimes a small circle and sometimes a large one, a good illustration of some of the principles of solid geometry. In this work he easily gets the poles, cardinal points, the meridian, the equinoctial, the hour-angle, declination and daily change of the Sun's motion.

In a similar way the Moon's path is studied, except that the stars aid in tracing the path.

In this work the student will find a little interesting pictorial history in the use of an instrument for observation like the old cross-staff, an old-time picture of which is given to show how it was used in very early times. The length of the month, the node of the Moon's orbit and the error of the cross-staff are determined.

Next the author considers the diurnal motion of the stars, and the complete celestial sphere of the heavens. These two chapters cover about thirty pages and make a fairly good outline for further observation or for elementary work in connection with a suitable text-book. At this point in the development of his plan the author makes free use of the celestial globe, and the nautical almanac and shows the aspects of the planets at a given time, rising and setting of the Moon, twilight, orienting buildings by Sun observation, graduating a horizontal

sun-dial, graduating a vertical sun-dial, determining the path of the shadow by the globe and the hour index.

In the last chapter, the motions of the planets are considered in a very instructive way. The points are: Elliptic orbits are a result of the law of gravitation, properties of the ellipse, mean and true place of a planet, equation of the center, measurement of angles in radians, diagram of curtate orbit, finding the elements of an orbit from a diagram, place of a planet in its orbit, the true heliocentric longitude and latitude of a planet, geocentric longitude and latitude of a planet, perturbations, precession, the Julian day, right ascension and declination of the planets, and the path of Mars for the year 1907.

This glimpse at the broad field of elementary astronomy is rather surprisingly large for such a modest little book, and yet the author evidently is master of his plan, and the best thing about it all is the inexpensive apparatus necessarily employed from beginning to end. Any high school in this country could easily furnish all the apparatus needed for the observational work in this new book.

One of the gravest errors possible to the modern high school course is made when elementary astronomy is excluded from it, because of its great educational value and interest to the student mind. The reason for it is plain: teachers in these schools are not prepared in our colleges and universities to instruct in the elements of astronomy either by the old or the new method. Superintendents of these schools say they can not find teachers to do the work, so it has to be excluded.

Fr. J. G. Hagen, for some years Director of the Georgetown College Observatory, Georgetown, Virginia, has just been appointed Director of the Vatican Observatory, at Rome, and it is reported, that he sailed to take up that work, April ninth.

The Modification of the Earth's Attraction due to its Spheroidal Form. We have received a thoughtful article from a student in Astronomy in Cape Breton, on the modification of the Earth's attraction due to its spheroidal form, as the wording of the title puts it.

We notice, with pleasure the earnest attempt that the author has made to solve this very difficult problem in celestial mechanics, (for that is the branch of mathematics to which it really belongs) by the methods of elementary mathematics. Of course his results are radically wrong because the method of solution is not a proper one for such a question. It would be a surprisingly strange coincidence if such a method applied to such a question would bring out a result anywhere near the truth, for practical astronomy can test such results, and astronomers and reputable text-books in the science are in satisfactory agreement as to how attraction is modified by the Earth's spheriodal form. The Earth's form and size have been measured with a good degree of accuracy by methods of observation and of reduction from work at many points on its surface and the results do not leave any large doubt in the mind of physicists and mathematicians competent to judge.

A prominent reason why the author of the paper referred to has gone wrong is the fact that he has treated the variations of gravity at the surface of the Earth without taking into account the effect of of the Earth's rotation, or the consequence of centrifugal force at the Earth's equator and elsewhere.

Still further; his comparison of the value of the Earth's attraction at the

poles with its value on the surface of a homogeneous sphere of equal mass is not applicable, because the comparison should be made between different points of a rotating spheroid.

We think the author has not carefully read reliable text-books if he concludes that the observed variations of gravity at different points on the Earth's surface are due to Earth's compression. The true statement is that the compression and the variation of gravity are alike consequences of rotation.

This question and a number of others akin to it, have come to us from time to time in the past, and we have been looking for the opportunity to present a series of articles in which the methods of their discussion might be such that students of practical astronomy could understand them, especially if they have had some training in the higher mathematics. Such help is really needed, and we hope still to furnish it.

Work at Lick Observatory.—R. G. Aitken has been making a series of observations on the satellites of Uranus during the last two years.

Also attention has been given to the satellites of Saturn, and the fifth satellite of Jupiter.

He also has recently published his ninth list of double stars, this one containing three hundred and fifty new ones.

The amount of excellent work that Mr. Aitken is doing at Lick Observatory is simply prodigious.

Shadow-Bands.—An interesting paragraph appears in the April number of the *Observatory*, in relation to shadow-bands as observed during the total solar eclipse of last August. It is especially noteworthy because made by experienced observers, and because some facts are noted that have been rarely observed before, and because of the suggestion that the shadow-bands seen during a total eclipse may be only atmospheric phenomena.

The report referred to was by Dr. Raoul Gautier, of the Geneva Observatory who observed the eclipse from Santa Ponza, on the island of Majorica, Mediterranean Sea. Among the party was the well-known, skillful observer Mr. Forel. He says:—"The weather was not favorable: the sky was covered with clouds of varying thickness, from a simple whitish veil, up to an opaque screen entirely masking the Sun. A rather strong wind blew from the southwest.

Some seconds before totality, and for some seconds only, we saw shadow-bands in the form of wavy lines not at all sharp; the most accentuated were distant one from the other by about perhaps a metre, and between them lines less well marked, from three to five centimeters broad, vertical upon the vertical walls, parallel to the meridian on the ground. These bands were affected by a motion of trepidation, of vibration about their position, but there was no lateral displacement, no running in any definite direction. This last part of the observation—the absence of lateral displacement in a definite direction—we both affirm, M. Fontsere and I, according to what we saw at Santa Ponza. We know this is in contradiction to observations make at Palma, but we adhere to our statement."

Compare this with what also appears in Dr. Gautier's report, the words of M. C. Four about an observation that he made in 1852. He said: "At the instant when the first ray of the Sun appeared at sunrise, immediately I saw for one or two seconds something resembling waves, alternately dark and light moving on the wall of my room." It is now claimed that others have witnessed

this same thing when the Sun is rising above the horizon, or passes from behind a mountain, or from behind a roof. Such bands are said to be sharply defined up to the time when about one-third of the Sun's diameter is uncovered. After that they are less distinct. It is also noticed that the movements of the bands vary according to the state of the atmosphere; if calm, they are slow, but more rapid in a strong wind.

PUBLISHER'S NOTICES.

Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

All Drawings for publication should be done in India ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of engraving now most generally used.

Proofs will generally be sent to authors living in the United States, if copy is furnished before the first of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

Renewals.—Notices of expiration of subscription are sent directly after the last number of this publication for which payment has been made. It is especially requested that subscribers will send renewal, or order for renewal, promptly as this publication will not be continued beyond the time for which it has been ordered.

Astronomical News.—It is very much desired on the part of the management, that brief news paragraphs of astronomical work in all the leading observatories of the United States be furnished to this publication, as regularly and as often as possible.

The work of amateur astronomers, and the mention of "personals" concerning prominent astronomers will be welcome at any time.

The building and equipping of new observatories, the manufacture, sale or purchase of new astronomical instruments, with special reference to improvements and new designs, and the results of new methods of work in popular language, will be deemed very important matter and will receive prompt attention. It is greatly desired that all persons interested bear us in mind and promptly respond to these requests.

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